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LYNAS, MARGARET A. Marfan's syndrome in Northern Ireland. An account of 13 families.
LYNAS, MARGARET A. AND MERRETT, J. D. Data on linkage in man. Marfan's syndrome in Northern Ireland.
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SIMPSON, H. R. Estimation of linkage on an electronic computer.
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BERG, J. M. AND STERN, J. Iris colour in phenylketonuria.
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Vol. 39, No. 4 *CONTENTS* October, 1958

Ecology of the riffle insects of the Firehole River, Wyoming ..... *Kenneth B. Armitage*
Daily movements of desert pupfish, *Cyprinodon macularius*, in shore pools of the Salton Sea, California ..... *George W. Barlow*
On fluctuations in population density of the rice stem borer *Chilo suppressalis* ..... *Syunro Utida*
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A study of louse populations on the meadow vole and deer mouse ..... *Edwin F. Cook and James R. Beer*
Forest and adjacent burn in the Tillamook Burn Area of Northwestern Oregon ..... *Bonita J. Neiland*
The availability of plant seeds to bobwhite quail in Southern Illinois ..... *Theodore A. Bookout*
Germination and growth of ephemerals induced by sprinkling a sandy desert ..... *Lloyd Tevis, Jr.*
A population of desert ephemerals germinated by less than one inch of rain ..... *Lloyd Tevis, Jr.*
Interrelations between the harvester ant *Veromessor pergandei* (Mayr) and some desert ephemerals ..... *Lloyd Tevis, Jr.*
An analysis of radial growth of beech in a Central Ohio forest during 1954–1955 ..... *Harold C. Fritts*
Vegetation changes on a southern Arizona grassland range ..... *R. R. Humphrey and L. A. Mehrhoff*
A study of prairie remnants in Southeastern Wisconsin ..... *Philip B. Whitford*
Native grassland of Southwestern Iowa ..... *J. E. Weaver*
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The relationship between the habitat preferences of hatchling *Chelydra serpentina* and the physical structure of the vegetation ..... *Owen J. Sexton*
Observations on red fox behavior ..... *Robert E. Vincent*
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The core-freezer—a new sampler for lake sediments ..... *Joseph Shapiro*
Underwater sounds produced by males of the blenniid fish, *Chasmodes bosquianus* ..... *William N. Tavolga*
The influence of light intensity on the nocturnal emergence of the European chafer ..... *William G. Evans and George G. Gyrisco*
Dormancy during the larval stages of the trematode *Schistosoma mansoni* in snails estivating on the soil of dry natural habitats ..... *F. S. Barbosa and I. Barbosa*
Floating communities of algae in a North Carolina pond ..... *Ronald C. Phillips*
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CHEMICAL ASPECTS OF RECENT HYPOTHESES ON PROTEIN SYNTHESIS

By I. D. RAACKE

(Post-doctoral Fellow of the American Cancer Society)

Virus Laboratory, University of California, Berkeley

ALTHOUGH a variety of hypotheses on the mechanism of protein synthesis has been proposed over the years, it is fair to say that all current ones have to take into consideration a number of recent developments in the field of amino acid activation and incorporation, and therefore, broadly speaking, follow the general scheme represented in Fig. 1.

The following abbreviations are used throughout: ATP, ADP, and AMP for the three adenosine phosphates; GTP, GDP, UTP, and CTP for the corresponding phosphates of guanine, uracil, and cytidine; PP for pyrophosphate; RNA and DNA for ribonucleic and deoxyribonucleic acids, respectively; RNP for ribonucleoprotein; and TCA for trichloroacetic acid.

This over-all sequence of events has been confirmed from a number of sources and seems to be fairly well established at present, especially as far as mammalian systems are concerned. It should be pointed out, however, that it relates only to the synthesis of proteins in the microsomal fraction of the cell; and that, although quantitatively at least, the microsomes probably represent the most important site of protein synthesis in the cell, other cellular structures are nevertheless capable of making protein. For example, protein synthesis has been demonstrated in isolated nuclei (Allfrey, Mirsky, and Osawa, 1957) and mitochondria (Simpson, McLean, Cohn, and Brandt, 1957), and it is quite possible that these structures possess independent mechanisms for the activation of the amino acids and for their incorporation into protein. We shall not, however, concern ourselves with these possibilities.

The scheme (Fig. 1) can be divided roughly into two parts: the activation of amino acids up to and including the soluble RNA-compound, and the combination of activated amino acids into peptide chains. The first part of the scheme is relatively well documented, but the second part is completely unknown and it is easy to see that there is ample room for speculation as to the actual mechanism of the steps involved; and there has, indeed, been no shortage of proposed schemes. In order to deserve serious consideration, however, a proposed mechanism must not only be consistent with all biochemical observations, but it must also be consistent with certain fundamental facts of organic chemistry. It is true, of course, that enzymes are incomparably more clever than organic chemists, but they are nevertheless only catalysts—which means, they can accelerate certain reactions, but cannot achieve any combinations that are chemically impossible. And in fact, every enzymatic reaction, no matter how improbable it may have seemed at first to the classical organic chemist, when

examined in detail has been shown to proceed by a series of steps perfectly feasible from a chemical point of view. This consideration of chemical feasibility and logic becomes even more important when we come to protein synthesis. In order to avoid the problem "of how the enzyme that makes the enzyme is made," it has generally been considered desirable, if not essential, that the last steps in the synthesis of proteins should proceed spontaneously.

Let us then examine the chemical plausibility and feasibility—potential at least—of the different reactions on the path from amino acids to proteins that are under most active consideration at the present time. Needless to say, only reactions which can take place with a relatively high rate in aqueous solutions at physiological *p*H's and temperatures can be of value.

Before we get very specific, however, I would

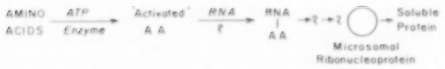

FIG. 1. OVER-ALL SCHEME OF MICROSOMAL PROTEIN SYNTHESIS

like to mention some points of terminology. A displacement reaction of the type: $AB + C = AC + B$ is described by the organic chemist as proceeding by a nucleophilic (or electrophilic) attack of C on A resulting in the displacement of B. If this were an enzymatic reaction, however, we would describe it as a transfer reaction, in which A is transferred from B onto an acceptor, C. The enzyme is pictured as labilizing the bond A–B, picking up A and unloading it on C; and depending on the willingness of C to accept A, we speak of a "good" or of a "bad" acceptor. I find this picture very useful and will use it to describe even some of the non-enzymatic reactions, although this is not, of course, strictly correct. I also hope that the chemists will be forbearing if I speak of this or that bond being broken or labilized, leaving this or that group free to be transferred. I only mean that some particular group is susceptible to nucleophilic attack.

It is furthermore customary in biochemistry to relate the ease with which A is transferred to C to its state of "activation"; that is, if the group A in linkage with B reacts readily with a given acceptor (or a class of acceptors) and without the supply of external energy, A is said to be "activated" and the bond A–B is termed a "labile" bond or, in certain cases, a high-energy bond. These are obviously unpopular terms with physical chemists, and they are indeed loose terms and to a certain extent misleading, but nevertheless so useful that I shall use them freely.

We should keep in mind, however, that "activation" in the biochemical sense is not related to and should not be confused with the formation of an activated complex prior to the reaction proper. Similarly, the energy released in the splitting of an "activated" or "high-energy" bond is free energy (ΔF) and not energy of activation (ΔH^*).

Finally, when a bond or a compound is referred to as being "unstable" or "labile", kinetic rather than thermodynamic instability is usually implied.

AMINO ACID ACTIVATION

It is well known that the reaction of the amino group of one amino acid with the carboxyl group of another to form a peptide bond requires a considerable amount of energy; and since cells cannot heat their reactants and do not generally have a built-in ultraviolet lamp, the most convenient way to obtain this energy is to have it trapped into a chemical bond. In other words, one of the groups must be activated so that it can be transferred onto the appropriate acceptor. Which one is it? I cannot go into the evidence here, but it has been shown over and over that it is, in fact, always the carboxyl group, and not the amino group, which is activated (Lipmann, 1941; for reviews of the evidence see Borsook, 1955, Wieland and Pfleiderer, 1957, and Lipmann, 1958).

It is interesting to note that all chemical syntheses of peptides so far devised likewise proceed by a nucleophilic attack of an unsubstituted amino group on the carbon of an activated carboxyl (Goodman and Kenner, 1956). The variety of substituents used by the organic chemist to achieve this activation is quite impressive, but the only ones that need concern us here are those which are also found in the cell. For the sake of convenience we

shall group these into three types:

1. —C(=O)—O*R*, where O*R* can represent a phosphate or a monoesterified phosphate such as a nucleotide, or a phenol, or certain special alcohols.

2. —C(=O)—S*R*, i.e. thioesters, where S*R* could be coenzyme A (CoA), glutathione, cysteine, and perhaps other SH compounds not as yet identified.

3. —C(=O)—N—*R*, where N*R* could be imidazole or an amide, or sometimes even ammonia.

In a sense all of these compounds can be regarded as mixed acid anhydrides formed by the combination of two acids through the loss of water. In general, it is true that the stronger the original acids, the greater is the tendency of the anhydride to recombine with water and thereby to regain the thermodynamically (as well as kinetically) more stable configuration; hence the more unstable the anhydride is going to be in aqueous solution, and especially at those *p*H's where one or both of the component acids are ionized, i.e., are in their most stable configuration. Most carboxylic acids are completely ionized at *p*H 7 and hence all the compounds in the above categories are unstable at neutral *p*H's, the exact rate of hydrolysis depending among other things on the *p*K's of the two acids.

Studies on the mechanism of the hydrolysis of anhydrides (Koshland, 1952; Wieland and Stimming, 1953; Emery and Gold, 1950) have shown that at intermediate *p*H values it proceeds by a nucleophilic attack of the oxygen of water on the central atom of one of the acid groups. If we therefore substitute another nucleophilic reagent for water, we will obtain one of the acids free and the other in the form of a derivative of the reagent used, the latter always being the most electrophilic of the two. In the anhydrides listed above, neither O, nor S, nor N can begin to compete with the C of the carboxyl group for electrons, and therefore these esters, thioesters, and amides act exclusively as acylating agents, despite the fact that the carboxylic is the stronger acid of the two. It has indeed been shown that all of these compounds can acylate the amino group of amino acids under physiological conditions, *in vitro* (Wieland and Pfleiderer, 1957).

When the pertinent atoms of the two acids have a comparable affinity for electrons, as is the case, for example, with mixed anhydrides of two carboxylic acids or of a carboxylic and phosphoric acid, the direction of the split is determined by the stabilities of the products, and often a mixture of derivatives is obtained. In the case of hydrolysis, the direction of the split is determined by the *p*K's of the acids (it being the weaker one which picks up the oxygen from water), but with other reagents the stabilities of the particular derivatives may well override the influence of *p*K. In addition there might be special electron shielding or stereochemical effects which may change the nature of the derivatives obtained.

So much for the general properties and the mode of reaction of mixed anhydrides. Let us now proceed to the specific compounds which are pertinent to the subject under discussion.

It has been known for a long time that ATP was needed for the biosynthesis of a peptide bond, and it was therefore postulated more than fifteen years ago by Lipmann (1941) that compounds analogous to acetyl phosphate served as the primary activated form of amino acids. However, no further evidence for such amino acid phosphates was found, and there was no progress at all in the identification of activated precursors of protein until about three years ago, when De Moss and Novelli (1955, 1956) and also Berg (1956) found amino-acid-dependent exchanges of radioactive pyrophosphate with the two terminal phosphates of ATP in bacterial extracts. At about the same time the existence of such a system in the soluble fraction of liver required for the incorporation of amino acids into microsomal protein was demonstrated by Hoagland (1955; Hoagland, Keller, and Zamecnik, 1956). The pyrophosphate exchange, as well as the incorporation of amino acids, was inhibited by hydroxylamine. Furthermore, when the soluble fraction was incubated with ATP, amino acid labeled in the carboxyl group with O^{18}, and hydroxylamine, the amino acid was recovered as a hydroxamate and the O^{18} appeared in the phosphate group of adenosine-5′-phos-

phoric acid (AMP) and not in the pyrophosphate (Hoagland, Zamecnick, Sharon, Lipmann, Stulberg, and Boyer, 1957; Bernlohr and Webster, 1958). This is strong evidence suggesting that the activation of the amino acid takes place through phosphorylation of the carboxly group by the ribose-bound phosphate of ATP, resulting in the formation of a mixed acid anhydride.

Amino-acid-activating enzymes have now been found everywhere they have been looked for, and several have been isolated in a highly purified state. The only one which has been studied in any detail, however, is a tryptophan-activating enzyme isolated from beef pancreas by Davie, Koningsberger, and Lipmann (1956).

The properties of this enzyme agree with observations made in crude systems and can be summarized as follows:

1. It is specific for ATP.

2. It binds both ATP and tryptophan (Try) with high affinity and non-competitively; ADP in high concentrations interferes with the binding of ATP, but AMP is not bound.

3. It catalyzes a rapid exchange of PP^{32} with the terminal phosphates of ATP, but no net synthesis of ATP occurs.

4. It catalyzes a less rapid reaction with hydroxylamine to give Try-hyrdoxamic acid and an equivalent liberation of PP.

5. During this reaction, O^{18} from the carboxyl group is transferred to the phosphate of AMP.

6. The PP exchange reaction is inhibited by high concentrations of NH_2OH and of Try.

7. The formation of hydroxamic acid is inhibited by PP.

8. Added AMP does not exchange with the ATP.

From these observations some fairly obvious conclusions as to the mechanism of the activation reaction can and have been drawn. Because of observation (2), the enzyme must have at least two independent binding sites, one for Try and the other for ATP. The binding of the Try must involve the indole group and not the two functional groups of the amino acid. Moreover, because of the absence of an ATP-AMP exchange, the enzyme does not seem to possess an acceptor for the activated acyl group of the amino acid. The binding of the ATP must, to some extent, involve the adenine, but since AMP is not bound, binding must occur through the pyrophosphate group, possibly by means of Mg. Observations (3), and (4), and (5) corroborate the conclusions drawn from the crude systems and again suggest the formation of an amino acid–adenosine-5′-phosphoric acid mixed anhydride, also known as an amino acid adenylate.

Since, however, numerous attempts to isolate such amino acid adenylates directly from the incubation mixtures had for a long time remained unsuccessful, several of these compounds have been synthesized and their properties studied (De Moss, Genuth, and Novelli, 1956; Wieland and Pfleiderer, 1957; Berg, 1957; Karasek, Castelfranco, Krishnaswamy, and Meister, 1958; Castelfranco, Moldave, and Meister, 1958). They were found to be substrates for the activating enzymes in so far as added adenylates were quantitatively converted into ATP, but this reaction is not specific. Tryptophan-activating enzyme, for example, can synthesize ATP from all the amino acid adenylates tested (Novelli, 1958), as well as from the adenylate of D-tryptophan (Karasek et al., 1958).

[Karasek et al. (1958) have recently obtained direct evidence for the enzymatic formation of adenyl tryptophan by isolating a small amount of this compound after incubating highly purified tryptophan-activating enzyme with Try-C^{14} and ATP.]

This low specificity of the enzyme with respect to ATP synthesis shows again that the two binding sites of the enzyme can function independently, and that it can catalyse a phosphorus to oxygen split of the adenylate (amounting to a transfer of the AMP moiety onto pyrophosphate) without binding the amino acid moiety. On the other hand, the enzyme seems to catalyze a carbon to oxygen split only when both binding sites are occupied, as demonstrated by the specificity for L-tryptophan and ATP with respect to hydroxamate formation (Davie et al., 1956).

As expected from earlier studies on mixed anhydrides of amino acids and free orthophosphoric acid (Bentley and Netter, 1953; Katchalsky and Paecht, 1954), or substituted phosphoric acids (Chantrenne, 1950), the adenylates were indeed very unstable at neutral *p*H's, with a half life of the order of 10 min-

utes (see also Table 1). Because of this instability even in the absence of any acceptors other than water, it is not surprising that attempts to isolate adenylates from an "enzyme soup," teeming with acceptors for both the acyl and the phosphoryl groups, should have met with failure. More puzzling is the fact that *in vitro* the mixed anhydrides react almost instantaneously with equivalent amounts of hydroxylamine, whereas very high concentrations of the latter (1–2 *M*) have to be used in order to obtain hydroxamate formation in the presence of enzyme.

This discrepancy in the reactivities of the synthetic and the enzymatic products is most easily explained by assuming that the adenylate, once formed, remains firmly attached to the surface of the enzyme (Hoagland, 1955; Davie et al., 1956). Since, however, as we have seen, the attachment of the adenylate to the enzyme does not occur through its anhydride bond, there must, in addition, be some mechanism of shielding this bond from attack by hydroxylamine. It is unlikely that the enzyme surface itself could be responsible for this shielding, since molecules larger than hydroxylamine, such as pyrophosphate and, in the amino-acid-incorporating system, another acceptor for the activated amino acid, have free access to the bond in question. It is therefore proposed that the pyrophosphate formed as a result of the reaction between ATP and the amino acid also remains attached to the enzyme, and in such a way as to shield the acyl group of the amino acid. A schematic representation of this arrangement is given in Fig. 2. Any acceptor for the amino acyl group will thus have to displace the pyrophosphate from the surface of the enzyme before it can react.

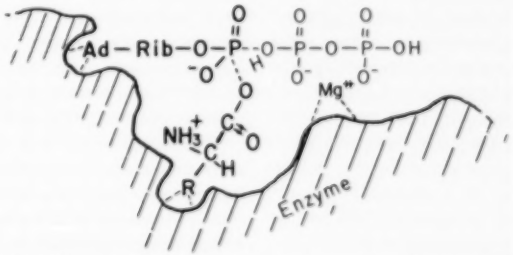

FIG. 2. SCHEMATIC REPRESENTATION OF AN AMINO-ACID-ACTIVATING ENZYME

TRANSFER OF THE ACTIVATED AMINO ACID TO OTHER ACCEPTORS

In order to understand the role of the amino-acid-activating enzymes, it is useful to consider again the mode of reaction of mixed anhydrides. As we have seen, the adenylates would be expected to take part in both acylating and phosphorylating reactions; and since secondary phosphoric acid, with a pK of about 7, is a weaker acid than an amino acid, one would expect the adenylates to be slightly better phosphorylating than acylating agents. That this is true for the enzymatic reaction is brought out by the relatively slow reaction with hydroxylamine contrasted with the rapid reaction of the synthetic adenylates with pyrophosphate to form ATP (De Moss et al., 1956; Novelli, 1958), by the exchange of Try-C^{14} with added tryptophan adenylate (Karasek et al., 1958), and of course, by the rapid PP-ATP exchange reaction, which is nothing more than a phosphorylation of the added pyrophosphate by the adenylate. Every time this happens, of course, free amino acid is regenerated, so that from the point of view of getting amino acid incorporated into a peptide chain, the PP-ATP exchange is a most undesirable reaction, and the best conditions for protein synthesis will be those which are least favorable for this exchange.

Experiments designed to demonstrate catalysis of an acylating reaction of the adenylates by the enzyme have so far remained inconclusive, because of the high non-enzymatic reactivity of these compounds. Castelfranco et al. (1958), for example, found that proteins could be labeled by C^{14}-amino acid adenylates even in the absence of active enzyme. It should be pointed out that this reactivity also prevents

a direct demonstration of the adenylates as intermediates in protein synthesis, and it is not impossible that they may turn out to be side-products. The amount of circumstantial evidence, however, seems to justify discarding this possibility for the present, at least.

In order to get the amino acid incorporated into peptide linkage we will have to get it off the activating enzyme in the form of a carboxyl derivative. This, however, is no easy matter, since, as we have seen, we not only have to remove the pyrophosphate, but we also have to avoid other phosphorylation reactions by the adenylyl group. Nothing positive is known about the mechanism of this transfer, but it might be useful to visualize the structural requirements of such an acceptor. First, in order to displace the pyrophosphate and get the acceptor bound to the enzyme at the same time, there is nothing better than another pyrophosphate. It should not, however, be a free pyrophosphate—since this would be phosphorylated by the adenylyl group of the mixed anhydride—but rather a substituted one, such as a nucleoside pyrophosphate. Secondly, one wants a structure which is a good acceptor for an acyl group but a poor one for a phosphoryl group. This could be an SH, a reactive OH, or the NH of an imidazole or amide group.

Among the known vitamins and cofactors there are, of course, several with the necessary structural requirements outlined above. The first to come to mind is CoA, but so far it has not been possible to demonstrate a CoA requirement for amino acid incorporation into mammalian or plant microsomes. Nevertheless, this vitamin seems to be essential for the incorporation of amino acids into the proteins of hen oviducts (Hendler, 1958); and it does, of course, the job of displacing activated fatty acids from their activating enzymes (Berg, 1955). Vitamin B_{12} also fits the structural requirements, and it has, indeed, been claimed to be essential for amino acid activation and subsequent incorporation into rat liver microsomes (Wagle, Mehta, and Johnson, 1957, 1958), but this requirement has not yet been confirmed by other authors. It is quite possible that different systems have different cofactor requirements, and some may even be capable of transferring the activated amino acid directly to a macromolecular acceptor. It is also possible that the acceptor is firmly bound to the activating enzyme and the competing pyrophosphate is removed by microsomal pyrophosphatase (Elliott, 1957). Some evidence in favor of this alternative in the case of the trytophan-activating enzyme has recently been presented by Weiss, Acs, and Lipmann (1958). It seems that in this case the acceptor is ATP, and the product 2′(3′)-tryptophanyl-ATP (F. Lipmann, pers. commun.), although it is quite possible that this is a side-product which may even be formed non-enzymatically. For lack of further information, however, all one can ask at present is the question: in what form does the labeled amino acid appear next?

SOLUBLE RNA-AMINO ACID COMPOUNDS

It has been found in a number of systems, such as liver (Hoagland and Zamecnik, 1957; Hoagland, 1958), *E. coli* bacteria (Berg, 1958), and yeast (Koningsberger, Van der Grinten and Overbeck, 1957), that amino acids appear bound to certain soluble RNA fractions of rather low molecular weight. If such RNA containing bound amino acid is isolated by appropriate methods and then incubated with amino-acid-activating enzymes, ATP, GTP, and microsomal particles, most of the amino acid can be transferred from the RNA to the microsomal ribonucleoprotein, where it appears in peptidic linkage (Hoagland and Zamecnik, 1957). This "acceptor" RNA has also been isolated in a protein-free state (Schweet, Bovard, Allen, and Glassman, 1958; Schweet, Glassman, and Allen, 1958; Ofengand, Bergmann, and Berg, 1958; Berg, and Ofengand, 1958) such that if incubated with ATP, an amino acid, and the appropriate activating enzyme, the amino acid becomes bound to the RNA.

This RNA is specific RNA, in the sense that commercial RNA or micrsomal RNA do not serve as acceptors for the activated amino acid. There also is some evidence that there is a specific RNA for each amino acid, or at least that there are specific loci on the RNA, since, when more than one kind of amino acid is given, the labeling seems to be additive and non-competitive.

The next question that arises is the nature of the bond between the amino acid and the RNA. A brief survey of the available groups will limit the possibilities. On one side we have, of course, the OH and NH_2 groups of

the purine and pyrimidine bases, but these are supposed to be involved in H-bonding to give shape to the RNA molecule and therefore do not seem to be very likely candidates. Then, on the other side, we have all the primary phosphoric acid groups of the backbone, one secondary phosphoric acid group of the terminal nucleotide and, finally, any free hydroxyl groups on the ribose residues, i.e., those in the 2′ position and one 3′ of the terminal ribose. Since, theoretically, each of these groups could combine with either the amino or the carboxyl group of the amino acid, we could have mixed anhydrides of the amino acid with either secondary or primary phosphoric acid groups, phosphoamidates, or ribose esters of amino acid. In order to further narrow down the possibilities, let us consider the known properties of such an RNA-bound amino acid. These are as follows:

1. It is unstable in alkali, "quite stable" at neutrality, "stable" in mild acid (Hoagland and Zamecnik, 1957; Schweet et al., 1958a, b; Ofengand et al., 1958; Koningsberger et al., 1957).

2. When incubated with hydroxylamine at 37°C., *p*H 7.6–7.8, it reacts to give amino acid hydroxamate (Hoagland and Zamecnik, 1957; Koningsberger et al., 1957; Ofengand et al., 1958). At *p*H 7 and with 0.8 *M* hydroxylamine, the half-time of reaction is 3 minutes (Berg and Ofengand, 1958).

3. The amino acid is rapidly liberated by ribonuclease (Hoagland and Zamecnik, 1957; Schweet et al., 1958a, b; Berg and Ofengand, 1958; Ofengand et al., 1958).

4. It does not react with ninhydrin in the Van Slyke reaction (Hoagland, Stephenson, Scott, Hecht, and Zamecnik, 1958).

The last of these observations rules out any non-chemical binding of the amino acid, and together with (2) shows that the binding occurs through the carboxyl group of the amino acid. Because of the observed stabilities and the fact that the amino acid is liberated by ribonuclease, binding on the bases also seems to be ruled out. We are then left with the following possibilities: (1) A mixed anhydride with the primary phosphoric acid groups. The latter, however, are very strong acids, so that the anhydride would be expected to be extremely reactive and, as a matter of fact, it has not yet been possible to isolate such an anhydride from aqueous solution. (2) A mixed anhydride with the secondary phosphoric acid group of the terminal nuceotide. This, then, would be a compound completely analogous to our amino acid adenylate, which, as we have seen, has a half life of only 10 minutes at *p*H 7 (see also Table 1) and has never been isolated; whereas the RNA-amino-acid compound survives a lengthy incubation at *p*H 7 [its half life is 62 minutes (Berg and Ofengand, 1958)], can be heated at *p*H 4, survives a 24-hour dialysis, and can be isolated. It therefore does not behave like a mixed anhydride. Furthermore, it is difficult to see how a terminal nucleotide could be very specific.

We seem, thus, to have eliminated all the possible combinations except a ribose ester of an amino acid. But since an ester is usually thought of as a stable compound, and traditionally does not react with hydroxylamine under neutral conditions and in the cold, we must consider whether particular esters might be reactive enough to account for the observed properties of the RNA–amino-acid complex.

In our general discussion of the properties of mixed anhydrides we saw that by increasing the acid strength of either component, the reactivity of the mixed anhydride was also increased. We could then consider an alcohol to be a very weak acid, in which case any factor which decreases the *p*K of an OH group would make the corresponding ester more reactive. Considering, then, that the *p*K of, let us say, ethyl alcohol is about 18 and that of the 2′ OH of ribose is about 12, one would expect a difference of several orders of magnitude between the reactivities of an ordinary ester and one of ribose. Considering further that amino acids are generally stronger acids than fatty acids, one would expect a further increase in reactivity by passing from the fatty acid to the amino acid series. These predictions are, in fact borne out by the experimental data taken from the literature, as can be seen from Table 1.

Particularly noteworthy are the remarkable decrease in stability and increase in reactivity towards hydroxylamine in going from an ordinary ester to one of ribose. Because of the lack of quantitative data it is not possible to evaluate the difference between a fatty acid

and an amino acid ester in this series, but we can see that both are in an activated state according to the operational biochemical definition of the term. At any rate, the $t_{0.5}$ of the

in Fig. 3, with the amino esterifying the 2′ hydroxyl of a ribose residue. The reasons for choosing the 2′ rather than the 3′ hydroxyls as the site of esterification are as follows. In

TABLE 1

Comparison Between Some Mixed Anhydrides and Esters of Acetic Acid and Leucine

COMPOUND	RATE OF HYDROLYSIS			REACTION WITH NH_2OH at pH 7	REFERENCE
	ACID pH 1–6.5	NEUTRAL pH 6.5–7.5	ALKALINE pH > 7.5		
Acetyl phosphate†	$t_{0.5}^{(1-4.5)*}$ = 50 min.	$t_{0.5}^{(7.3)}$ = 200 min. $t_{0.5}^{(7.7)}$ = 80 min.	$t_{0.5}^{(10)}$ = 40 min. $t_{0.5}^{(11)}$ = 20 min.	rapid	Koshland, 1952
Acetyl adenylate	"Stable" at 100°C., pH 4	10% decomp. in 30 min. at pH 7.5	instant. decomp. at pH 10, 0°C.	$t_{0.5}^{37°}$ = 0.6 min.	Berg, 1955; Jencks, 1957
3′(2′)-Acetyl AMP	—	—	—	$t_{0.5}^{37°}$ = 5 min.	Jencks, 1957
Ethyl acetate	—	—	—	very slow	Chantrenne, 1948
Leucyl phosphate	"Stable" at pH 6.0	Rapid decomp. pH 7.0	Instantaneous decomp.	rapid	Katchalsky and Paecht, 1954
Leucyl adenylate	"Stable" at pH 5, 37°C	$t_{0.5}^{(7.0)}$ = 10 min.	$t_{0.5}^{(8.0)}$ = 4 min.	rapid	De Moss, Genuth, and Novelli, 1956
3′(2′)-Leucyl (valyl) AMP	"Rel. stable" at 22°C.	"Unstable"	Rapid decomp.	$t_{0.5}$ = 5 min.	Wieland, Niemann, and Pfleiderer, 1956; Wieland and Pfleiderer, 1957
Leucyl methyl ester				$t_{0.5}^{7.3}$ = 130 min. $t_{0.5}^{7.8}$ = 60 min.	Raacke, 1958

* Half-times of reaction at a pH indicated by the superscript in parentheses.

† Measurement made at 39°C.

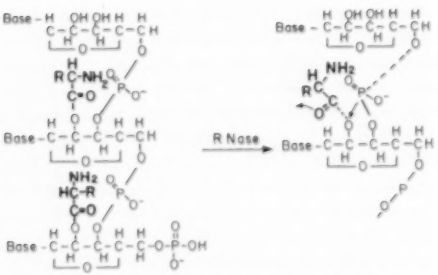

FIG. 3. PROPOSED STRUCTURE AND POTENTIAL REACTIONS OF AMINO ACIDS BOUND TO SOLUBLE RNA

RNA-bound amino acid with hydroxlyamine (3 min.) is more in line with that of ribose-acetylated AMP (5 min.) than with that of adenyl- acetate (0.6 min.).

It is therefore proposed that the structure of the RNA–amino-acid compound is as shown

an RNA molecule all of the 2′ positions are free, but only one terminal 3′ OH for each RNA molecule is unesterified. Esterification of the latter would limit each RNA fragment to one amino acid and, since the 3′ OH is at the end and there can be only four different terminal nucleotides, the specificitity of this position would seem to be rather limited. In the case of the 2′ hydroxyls, on the other hand, added specificity can be imparted by the two neighboring nucleotides. Considering, moreover, what is known about the mechanism of ribonuclease action, it is difficult to visualize how this enzyme would affect a terminal 3′ ester. If, however, one assumes that only 2′ OH's of pyrimidine nucleotides can serve as acceptors for the activated amino acid, it is easy to picture a mechanism for the displacement of the amino acid during the formation of a cyclic phosphate intermediate by ribonuclease and which is entirely consistent with the known properties of

the enzyme. Such a mechanism is also illustrated in Fig. 3. Finally, reaction with the 2′ OH would suggest why RNA, but not DNA, is needed for protein synthesis (inasmuch as the 2′ carbon of deoxyribose is the one lacking a hydroxyl group).

THE ROLE OF SOLUBLE RNA IN PROTEIN SYNTHESIS

In the present discussion we should keep in mind that we are following the fate of an amino acid, which, presumably, is on its way to form protein; and once we have located it on RNA, we must ask: what happens next? Is this RNA a template? Are peptide chains formed on it? We can see from Fig. 3 that if adjacent positions were filled, the spatial proximity of one acyl group to the amino group of the next amino acid could easily result in peptide bond formation, leaving us with activated peptides which are attached to RNA and which could be precursors for protein. This might very well be the origin of the activated, nucleotide-bound peptides isolated from yeast by Koningsberger et al. (1957). But this does not seem to happen generally, although at the moment there is no conclusive evidence against it. It is, however, fairly certain that no complete protein is formed at this stage, since this seems to require the presence of microsomal ribonucleoprotein particles. The transfer of the amino acid from the soluble RNA to the particle seems to require GDP or GTP (Hoagland and Zamecnik, 1957), but beyond that we do not have the faintest idea of what might be happening.

The main role of the particular RNA under consideration then seems to be that of a specific carrier of activated amino acids or, in some systems, of activated peptides. These amino acids might be said to be one step closer to forming proteins than they were in the form of the adenylates, since in the latter they often served merely to activate the phosphate group of adenosine-5′-phosphoric acid; whereas in the form of an activated ester their mode of reaction will be predominantly one of acylation.

Besides serving as an acceptor for activated amino acids, the soluble RNA seems, however, to take part in other reactions. It has been found by a number of workers (Zamecnik, Stephenson, Scott, and Hoagland, 1957; Edmonds and Abrams, 1957; Webster, 1957) that under certain conditions, the AMP part of ATP is incorporated into soluble RNA, predominantly at the end of a chain. With plant systems (Webster, 1957; Holley, 1957; Holley and Prock, 1958) and with yeast (Webster, 1957) but not liver, there is at the same time an exchange of added AMP with ATP, and consequently an incorporation of the former into the RNA. The incorporation of ATP into RNA as well as the AMP-ATP exchange, when it occurs, requires the presence of amino acids and amino-acid-activating enzymes, and is inhibited by the same factors inhibiting the incorporation of amino acids into the microsomal protein. The over-all relationships are schematically represented in Fig. 4.

The incorporation of the ATP shows that

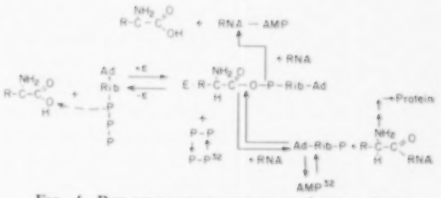

FIG. 4. RELATIONSHIPS BETWEEN AMINO ACID ACTIVATION AND INCORPORATION OF ADENINE NUCLEOTIDES INTO RNA

the phosphorylating tendencies of the amino acid adenylate cannot be overcome entirely. Sometimes, then, we have acylation (of the ribose 2′ hydroxyls, according to our proposed structure) and sometimes phosphorylation of the terminal 3′ hydroxyl of the RNA, although there is no evidence to show that both these reactions can take place on the same RNA molecule. Here we have, then, a truly amino-acid-dependent incorporation of nucleotide into RNA—and in a crude system presumably also of adenine nucleotide precursors—but this incorporation is not *necessary* for protein synthesis. As a matter of fact if the phosphorylation of RNA could be blocked, we would have more activated amino acid available for protein synthesis, but it is also easy to see that it would be extremely difficult to effect such a blockage without at the same time interfering with the activation of amino acid. If, on the other hand, protein synthesis were blocked beyond the stages shown in Fig. 4, the incorporation of

nucleotide would probably be increased. Some such mechanism might explain the effect of chloramphenicol on protein and RNA syntheses, since this antibiotic while inhibiting the incorporation of labeled precursors into proteins, in many cases actually stimulates the incorporation of nucleic acid precursors (see, for example, Gale, 1953).

THE INCORPORATION OF AMINO ACIDS INTO PROTEIN

As we have seen above, we don't know anything about the intermediary steps leading from the RNA–amino-acid compound to the formation of protein. But since synthesis of protein, or better, the incorporation of a labeled amino acid into TCA-precipitable peptide chains, does not occur in the absence of microsomal particles, we assume that the formation of such peptide chains takes place in or on the particles. In concerning ourselves with these events we are, however, at the same time entering the realm of pure speculation. It is useful, nevertheless, to distinguish between two possibilities, namely, the incorporation of a single, activated amino acid into an existing peptide chain, and the synthesis *de novo* of protein with the concurrence of a number of activated amino acids.

The Incorporation of a Single Amino Acid

Whether or not a single amino acid can be incorporated into protein in the absence of synthesis *de novo*, has been a hotly debated issue. It is a point of prime importance in deciding on the meaningfulness of incorporation experiments. The instances of freak labeling of protein by means of S–S bonds, through the ε-amino groups of lysine, etc., are sufficiently well known (Tarver, 1954). Recently, however, mechanisms have been elucidated by which an amino acid can be introduced *between* two other amino acids in peptide linkage without prior breakdown of the chain.

It has been known for a long time that a thioester can transfer its acyl group onto an amino group under physiological conditions, but ordinarily this reaction is too slow to be biochemically important. Wieland and his coworkers (1953), however, were able to show that the rate of transfer could be increased several hundredfold if the SH and NH_2 groups were on the same molecule, in sterically favorable positions, as for example in cysteamine or cysteine. Still, this reaction became of real biochemical interest only when it was shown by Wieland, Lang, and Liebsch, (1955) that not only a free amino group, but also a peptidic N could serve as an acceptor. The resulting diamide was unstable, and the ensuing acyl migrations could lead to incorporation of the amino acid into the peptide chain and to extensive rearrangements in the amino acid sequence. The particular example studied was the rearrangements of S-valyl-N-alanylglycylcysteamine upon neutralizing an acid aqueous solution of this compound. This was expected to yield three stable isomers, namely, the peptides Val.Ala.Gly.Cys, Ala.Gly.Val.Cys, and Ala.Val.Gly.Cys. All three were, in fact, isolated. If cysteine instead of cysteamine is used, the reaction is so rapid that the intermediate thioester cannot be isolated.

Similar insertions of an amino acid into an existing peptide chain have been demonstrated by Brenner and coworkers (1955) with amino acid esters of salicylic acid derivatives, and with N-imidazole-acylhistidine peptides. It is easy to see that the existence of a labeled amino acid in peptide linkage can no longer be considered sufficient evidence for the synthesis of the whole protein molecule.

Incorporation of Amino Acids by Synthesis of Protein de Novo

Let us assume that not one, but all the necessary amino acids arrive at the particle in some activated state $RHNH_2{-}C{-}\overset{O}{\overset{\|}{C}}{-}X$ and are going to form a protein. So what do they do? Everybody knows, of course, that the thing for them to do is to get lined up on a template and get "zipped" up. But how? One wants to avoid using enzymes, because then there is the problem of how to make the enzymes themselves. This means that the amino acids should be in a sufficiently activated state so that they will react spontaneously to form peptide chains. But since the amino acid sequence should be a specific one, one wants to avoid intermediates which will react indiscriminately. The reactivities of the intermediates should therefore be such that they will react at an appreciable rate only when placed in particularly favorable positions to

each other. And in order to get these particularly favorable positions, the best solution so far proposed is to have the amino acids firmly held by a template.

The idea of a template for protein synthesis has been current in biochemical speculations for about a quarter of a century, and people have pictured this template in many different ways. The generally accepted idea now among those who accept templates at all, is that it is nucleic acid in nature, probably of the RNA type. But how do the amino acids find their particular place on the template, and how are they held there? All sorts of physical and physico-chemical forces have, of course, been invoked, but there are no experimental data to show the adequacy of any of these.

Nevertheless, we must rely on specific affinities and particularly favorable stereochemical configurations in order to explain the specificity of a given amino acid sequence. Unfortunately, a careful examination of the available loci on the nucleic acid and of the side chains of amino acids fail to reveal any possibilities for hydrogen bonding of the required degree of specificity. It has furthermore proven to be very difficult to "code" a nucleotide sequence in such a fashion as to account for even the amino acid sequences so far shown to occur in proteins (Gamow, Rich, and Ycas, 1955; Brenner, 1957; Crick, Griffith, and Orgel, 1957). It can easily be shown that the combination of two nucleotides cannot provide enough information for the coding of the 20 odd amino acids found in proteins, and that a combination of three nucleotides provides too many choices. If, however, the combinations of three were restricted so as to use only non-overlapping triplets in the code, the correct number of choices could be provided (Crick et al., 1957). If, however, only every third nucleotide can carry a bound amino acid, the distances between the amino acids become too great to allow for peptide bond formation. From purely theoretical considerations, it is therefore considered unlikely that free amino acids can line up on a nucleic acid template, a conclusion which is, as we have seen, corroborated by biochemical observations.

Crick (1957) has suggested that the probability for obtaining specific amino acid sequences would be greatly improved if the amino acids were combined with small molecules termed "adaptors," which could bridge the gap between the nucleotides and which at the same time possessed the necessary structural requirements for a specific pattern of hydrogen bonding with the nucleic acid. The best candidates for such adaptors from a structural as well as a chemical and biochemical point of view seem to be nucleotides or nucleotide derivatives. One could also assume that the sterical requirements could be met by binding small, carboxyl-activated peptides (which may be synthesized on the soluble RNA as outlined above) to every third nucleotide; but the number of possible peptides containing three or more amino acids is very large, and the non-overlapping triplet code provides only for 20 specific choices. If, however, we assume that the specificity of the amino acid alignment does not depend on the nucleotide sequence of the template, but on the nature of the amino-acid–adaptor combination as well as on the loci on the nucleic acid as determined by a particular nucleotide and one of its two neighbors, we have enough variables to achieve, theoretically at least, any specific amino acid sequence, without having to sacrifice the stereochemical advantage which accrues from filling adjacent positions with activated amino acids.

Assuming, then, that the cell disposes of the necessary means for achieving any desired amino acid sequence, there are two remaining problems to be considered, viz., the mode of attachment of the activated amino acid to the template, and the manner in which the amino acids react to give peptide chains. Since the best way of keeping an amino acid in place on the template is by means of a chemical bond, the two problems are actually closely related and are best discussed together.

In considering the different hypotheses which have been put forward to explain the operation of the template (as a matter of fact, probably one for each investigator in the field) we shall not consider the "DNA-makes-RNA, RNA-makes-protein" type, since these are too vague for the purposes of discussing chemical aspects. Similarly, we shall not consider any hypothesis which is not explicit about the mode of linking the amino acids together. Especially since we do not want to invoke enzymatic magic, our hypotheses should contain well-defined steps

which are known to be chemically sound or which by extrapolation from known reactions are at least chemically probable. If there are any steps which are known to be unfeasible, the hypothesis must be rejected.

This is the case with the hypothesis of Dounce (1952), which presented the first chemically detailed mechanism for protein synthesis on a template. It envisaged the amino group of a series of amino acids activated by means of a phosphoamidate linkage (i.e., a phosphorus to nitrogen bond) with the phosphates of the nucleic acid backbone, and ready to attack the carboxyl group of the next amino acid. Not only has it been found experimentally that the carboxyl groups of the amino acids are not free, but it is also known that phosphoamidates are phosphorylating, and not aminating agents (Rathlev and Rosenberg, 1956; Chambers, Moffatt, and Khorana, 1957).

There are further restrictions of a biochemical nature which must be applied, the most serious one being that the release of soluble protein from the ribonucleoprotein particle does not proceed spontaneously, but also seems to require an energy source (Rabinovitz and Olson, 1956, 1957). This observation, together with the difficulty so far encountered in obtaining synthesis of soluble, non-microsomal protein in vitro (Littlefield, Keller, Gross, and Zamecnik, 1955; Rabinovitz, pers. commun. 1957; Simkin and Work, 1957; Campbell, Greengard, and Kernot, 1958) would seem to indicate that the completed peptide chain is still bound to the template by a rather stable bond, which is not susceptible to spontaneous hydrolysis.

The second biochemical restriction rests on the oft-observed, apparently obligatory relationship between protein synthesis and that of RNA (Pardee, 1954; Spiegelman, Halvorson, and Ben-Ishai, 1955; Brachet, 1955). As we have seen, there is a close relationship between the activation of amino acids and the incorporation of adenine nucleotides into soluble RNA. It is quite possible, and recent work by Hecht, Stephenson, and Zamecnik (1958) strongly suggests, that similar mechanisms exist for the incorporation of GTP, UTP, and CTP, and that most of the observed correlations between nucleotide and amino acid incorporation may be of this type. It is known, however, that synthesis and/or turnover of at least a small fraction of nucleic acids can also take place in the microsomal particles (Shigeura and Chargaff, 1957; Bhargava, Simkin, and Work, 1958). Therefore, hypotheses which provide a mechanism for the syntheses of both nucleic acids and proteins are to be favored.

Because of the above restrictions, the number of published hypotheses admissable for discussion is limited to the well-known hypothesis of Borsook (1957) and a recently published one by Michelson (1958a). In the Borsook hypothesis the amino acids are bound to the phosphates of the RNA backbone by mixed anhydride linkages. These, however, because of their great reactivity might be expected to react indiscriminately before the template can get completely filled. Furthermore, this kind of line-up presents "coding" problems, as we have seen above. Michelson envisages the reactive intermediates as mixed anhydrides between amino acids and cyclic 2′-3′-nucleoside phosphates. These are brought into close proximity in some unspecified way, and depending on their mode of reaction, are pictured as forming protein with or without simultaneous synthesis of RNA. It has been shown by Michelson (1958b) that the cyclic nucleoside phosphates are capable of polymerization to give RNA-like polynucleotide structures; but the mixed anhydrides would be expected to be even more reactive, so that unless they are formed *in situ*, they would probably react in solution, in a fairly random fashion. In both hypotheses, after completion of the peptide chain it would remain attached to a nucleotide by an anhydride bond, which is easily hydrolyzable and thus would not require further supply of energy for releasing the protein.

An alternative hypothesis is therefore proposed which grew out of earlier schemes developed in collaboration with C. S. Hanes of the University of Toronto. It accounts quite well for most of the observations about microsomal protein synthesis made to date, which, it must be admitted, often consist of only the barest hints interpreted with a great deal of wishful thinking. Considering the complexity and the vital importance of the process of protein synthesis in the economy of the living cell, it would indeed be surprising if any single hypothesis, no matter how ingenious, could provide a truthful picture of the actual mechanism.

As we have seen, the evidence at present suggests that although an occasional peptide may be formed, protein is not formed on the soluble RNA, but rather that the activated amino acid is passed on to other acceptors in or on the microsomal particles, which are the site of protein synthesis proper. Nothing is known about this transfer of the activated amino acid from the soluble RNA to microsomal ribonucleoprotein, but it seems that GTP is required for this step (Hoagland et al., 1958) and it may very well turn out that the other triphosphates are required as well. This suggests that the amino acid, from its rather stable combination with the soluble RNA—which can exist free in the cytoplasm—may again be transferred to a highly reactive phospho-anhydride linkage.

This transfer, from a highly reactive phospho-anhydride (adenylates) to an activated ester and back to a phospho-anhydride does, off hand, appear to be a waste of energy—and it is well known, of course, that the cell does not waste energy. With some effort, however, one could think of some rationalizations for such a sequence. The amino-acid-activating enzymes are in the cytoplasm, since that is where the highest concentration of free amino acids is found. ATP is much more plentiful than the other triphosphates, and is used in the primary activation of the amino acids to form adenylates. These, however, cannot exist in a free state, and hence must be protected from hydrolysis by the enzyme; but by remaining bound to the enzyme, they prevent the activation of more amino acids. An activated ester, then, would seem an ideal way of storing and transporting the activated amino acid, since it remains activated, but is now stable enough to exist free for finite periods of time.

As the immediate precursor of protein, the soluble RNA-AA ester has several disadvantages, however. As we have seen, there are "coding" problems when adjacent positions on a nucleotide chain are filled by unsubstituted amino acids, as would have to be the case if peptide chains are to be formed on the soluble RNA. Furthermore, because of the relative stability of the RNA-AA compound, the non-enzymatic reaction of the activated carboxyl group with the amino group of the next amino acid would be too sluggish. Therefore, the amino acids would again be transferred to highly reactive phospho-anhydride bonds, possibly with all four nucleotides. These, besides being very reactive—and hence eliminating the need for an enzyme in the final condensation to peptide chains—have the advantage over a ribose ester of activating the nucleotide as well as the amino acid moiety.

The problem of the extreme reactivity of these compounds could conceivably be met in two ways. First, by having them formed and react in situ, and second, by substituting the amino group of the amino acids involved in anhydride formation with a nucleotide. This increases the stability of the anhydride bond greatly, as has been shown with the carbobenzoxy derivatives of several adenylates (Castelfranco et al., 1958; Zioudrou, Fujii, and Fruton, 1958). The first alternative would still leave unsolved the problem of how the activated amino acid would get from the soluble RNA into the particles, and therefore the second alternative has been adopted in the present hypothesis.

The essential points of the present scheme, which is represented in Fig. 5, are as follows. The template consists of a ribonucleoprotein complex in which the bases of the RNA are then bound to the protein by means of hydrogen bonds, and the phosphate backbone of the nucleic acid remains available for reaction. Amino acids with their carboxyl groups in the form of nucleotide mixed anhydrides and with a substituent on the amino groups are supplied to specific positions—the specificity being determined by "coding" factors such as were discussed above—on the reactive surface of the template, and are bound there by means of phosphoamidate bonds. Although there are two highly activated types of linkages, the resulting complex would be relatively stable because, both functional groups of the amino acid being substituted, there is no opportunity for the acylating potential of the mixed anhydride to express itself. Similarly, there is no opportunity for phosphorylation by the phosphoamidate bonds.

Phosphorylation of the 3′ hydroxyls of the nucleotides by the phosphoryl group linked to the carboxyl group of the amino acid would, however, be possible. This then would be the starter reaction, a kind of trigger to unmask the reaction potential of the complex, and

would result in the formation of a nucleotide chain still attached to an amino acid on one end. As this nucleotide chain is formed, the carboxyl groups of the amino acids become free and, being in a favorable position, they will be phosphorylated by the phosphoryl groups of the template; but since these phosphoryl groups are very strong acids, the resulting anhydrides would be extremely reactive acylating agents and could be expected to react instantaneously with the newly liberated amino groups of the amino acids to give peptides. In actual practice, therefore, one would not expect the formal sequence of reactions as represented in Fig. 5; that is to say, the phosphorylation of the carboxyl groups (Step 3) would not have to wait until synthesis of the new RNA chain is completed, and the formation of peptide bonds (Step 4) would proceed almost as soon as the necessary reactive intermediates become available. It should also be pointed out that synthesis of new RNA in the present scheme is a possible, but not an obligatory feature. The nucleotidyl residues could also be transferred to acceptors other than the 3′OH of another nucleotide without affecting the synthesis of protein.

If the process is allowed to go to completion, the newly synthesized protein would be attached to the new RNA by its free carboxyl group, and to the RNA of the template by its free amino end group. Since the mixed anhydride bond is unstable at neutral *p*H's, it could be hydrolyzed non-enzymatically and the RNA released. The phosphoamidate bond, however, is not easily hydrolyzable at physiological *p*H's, so that the release of the protein from the template would require an enzymatic step, possibly involving ATP.

If, however, an actively synthesizing microsome population were stopped at an arbitrary time, one would expect a variety of products,

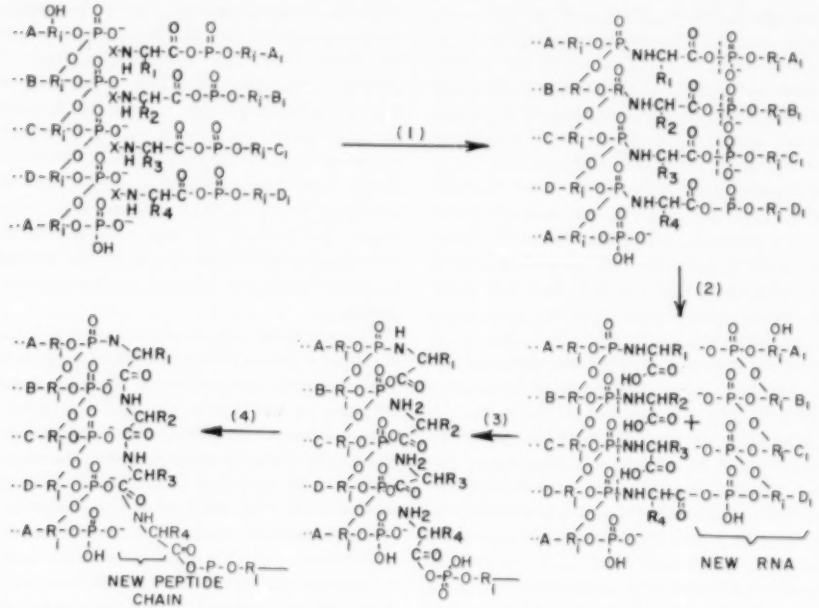

FIG. 5 PROPOSED SCHEME OF PROTEIN SYNTHESIS ON A RIBONUCLEOPROTEIN TEMPLATE

The symbols A, B, C, and D represent the four bases of the RNA template, and A_1, B_1, C_1, and D_1, the four bases of the new RNA. The dots to the left indicate hydrogen bonding to the microsomal protein. R_i represents ribose, and R_1, R_2, . . . etc. different side chains of amino acids. The heavy letters represent the structures of added amino acids which are transferred into the microsomal particle.

depending on the conditions used to stop the reaction and to isolate the products. Under alkaline conditions, one would expect amino acids and peptides of varying lengths bound to RNA by means of phosphoamidate bonds. After dinitrophenylation (with dinitrofluorobenzene under alkaline conditions) one would expect dinitrophenyl-peptides with a spectrum of end-groups representing all the amino acids of the particular protein being synthesized. Under mildly acid conditions, on the other hand, one might hope to isolate amino acids and peptides linked by their carboxyl groups to polynucleotides of varying chain lengths; and, finally, reaction with hydroxylamine in neutral or slightly acid solution should yield hydroxamic acids not only of amino acids, but of peptides as well.

It is, of course, of little value to present evidence from the literature in favor of a purely hypothetical, and of necessity, grossly oversimplified scheme, since such evidence can usually be found and used to support widely divergent hypotheses. It is interesting, nevertheless, that Potter and Dounce (1956, 1957) have claimed to have found amino acids and peptides joined to RNA by their amino groups, and Koningsberger et al. (1957) have indeed found in microsomes carboxyl-activated amino acids and peptides linked to nucleic acid fragments.

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LIST OF LITERATURE

ALLFREY, V. G., A. E. MIRSKY, and S. OSAWA. 1957. Protein synthesis in isolated cell nuclei. *J. gen. Physiol.*, 40: 451–490.

BENTLER, M., and H. NETTER. 1953. Synthese von Aminosäure - Phosphorsäure - anhydriden. *Z. physiol. Chem.*, 295: 362–367.

BERG, P. 1955. Participation of adenyl-acetate in the acetate-activating system. *J. Amer. chem. Soc.*, 77: 3163–3164.

——. 1956. Acyl adenylates: the interaction of adenosine triphosphate and L-methionine. *J. biol. Chem.*, 222: 1025–1034.

——. 1957. Chemical synthesis and enzymatic utilization of adenyl amino acids. *Fed. Proc.*, 16: 152.

BERG, P., and E. J. OFENGAND. 1958. An enzymatic mechanism for linking amino acids to RNA. *Proc. nat. Acad. Sci. U. S.*, 44: 78–86.

BERNLOHR, R. W., and G. C. WEBSTER. 1958. Transfer of oxygen-18 during amino acid activation. *Arch. Biochem and Biophys.*, 73: 276–278.

BHARGAVA, P. M., J. L. SIMKIN, and T. S. WORK. 1958. Incorporation of radioactive phosphorus into the ribonucleic acid of subfractions derived from guinea-pig-liver microsomes. *Biochem. J.*, 68: 265–269.

BORSOOK, H. 1955. The biosynthesis of peptides and proteins. *3me Congres internat. Biochemie*, p. 92–124.

——. 1956. The biosynthesis of peptides and proteins. *J. cell. comp. Physiol.*, 47, Suppl. 1: 35–80.

BRENNER, M., J. P. ZIMMERMANN, J. WEHRMÜLLER, P. QUITT, and I. PHOTAKI. 1955. Eine neue Umlagerungsreaktion und ein neues Prinzip zum Aufbau von Peptidketten. *Experientia*, 11: 397–399.

BRENNER, S. 1957. On the impossibility of all overlapping triplet codes in information transfer from nucleic acid to proteins. *Proc. nat. Acad. Sci. U. S.*, 43: 687–694.

CAMPBELL, P. N., O. GREENGARD, and B. A. KERNOT. 1958. Amino acid incorporation into serum albumin in microsome preparations from regenerating rat liver. *Biochem. J.*, 68: 18–19.

CASTELFRANCO, P., K. MOLDAVE, and A. MEISTER. 1958. Incorporation of amino acid molecules of amino acid-adenylic acid anhydrides into proteins. *J. Amer. chem. Soc.*, 80: 2335.

CHAMBERS, R. W., J. G. MOFFATT, and H. G. KHORANA. 1957. The preparation of nucleoside 5′-phosphoramidates and the specific synthesis of nucleotide coenzymes. *J. Amer. chem. Soc.*, 79: 4240–4241.

CHANTRENNE, H. 1948. Mixed anhydrides of benzoic and phosphoric acids. *C. r. Lab. Carsberg, Ser. Chim.*, 26: 231–241.

——. 1950. Synthèses peptidiques à partir d'un derivé du glycyl phosphate. *Biochim. biophys. Acta*, 4: 484–492.

CRICK, F. H. C. 1957. In *The structure of nucleic acids and their role in protein synthesis* (E. M. Crook, ed.). *Biochem. Soc. Sympos.*, 14: 25–26.

——, J. S. GRIFFITH, and L. E. ORGEL. 1957. Codes without commas. *Proc. nat. Acad. Sci. U. S.*, 43: 416–421.

DAVIE, E. W., V. V. KONINGSBERGER, and F. LIPMANN. 1956. The isolation of a tryptophan-activating enzyme from pancreas. *Arch. Biochem. and Biophys.*, 65: 21–38.

DE MOSS, J. A., and G. D. NOVELLI. 1955. Amino

acid dependent exchange reaction between inorganic pyrophosphate and ATP in microbial extracts. *Bacteriol. Proc.*, 125.

——, S. M. Genuth, and G. D. Novelli. 1956. The enzymatic activation of amino acids via their acyl-adenylate derivatives. *Proc. nat. Acad. Sci. U. S.*, 42: 325–332.

Dounce, A. L. 1952. Duplicating mechanism for peptide chain and nucleic acid synthesis. *Enzymologia*, 15: 251–258.

Edmonds, M., and R. Abrams. 1957. Incorporation of ATP into polynucleotide in extracts of Ehrlich ascites cells. *Biochim. biophys. Acta*, 26: 226–227.

Elliott, W. H. 1957. The breakdown of adenosine triphosphate accompanying cholic acid activation by guinea-pig liver microsomes. *Biochem. J.*, 65: 315–321.

Emery, A. R., and V. Gold. 1950. Quantitative studies of reactivities of mixed carboxylic anhydrides. *J. chem. Soc.*, 1443–1460.

Gale, E. F. 1953. Assimilation of amino acids by gram-positive bacteria and some actions of antibiotics thereon. *Advanc. Protein Chem.*, 8: 285–391.

Gamow, G., A. Rich, and M. Ycas. 1955. The problem of information transfer from the nucleic acids to proteins. *Advanc. biol. med. Phys.*, 4: 23–68.

Goodman, M., and G. W. Kenner. 1957. The synthesis of peptides. *Advanc. Protein Chem.*, 12: 466–626.

Hecht, L. I., M. L. Stephenson, and P. C. Zamecnik. 1958. Formation of nucleotide end groups and incorporation of amino acids into soluble RNA. *Fed. Proc.*, 17: 239.

Hendler, R. W. 1958. Amino acid turnover in "non-protein" fractions of hen oviduct in relation to incorporation into protein. *Fed. Proc.*, 17: 240.

Hoagland, M. B. 1955. An enzymatic mechanism for amino acid activation in animal tissues. *Biochim. biophys. Acta*, 16: 288–289.

——, E. B. Keller, and P. C. Zamecnik. 1956. Enzymatic carboxyl activation of amino acids. *J. biol. Chem.*, 218: 345–358.

——, M. L. Stephenson, J. F. Scott, L. I. Hecht, and P. C. Zamecnik. 1958. A soluble ribonucleic acid intermediate in protein synthesis. *J. biol. Chem.*, 231: 241–257.

——, and P. C. Zamecnik. 1957. Intermediate reactions in protein biosynthesis. *Fed. Proc.*, 16: 197.

——, ——, N. Sharon, F. Lipmann, M. P. Stulberg, and P. D. Boyer. 1957. Oxygen transfer to AMP in the enzymic synthesis of the hydroxamate of tryptophan. *Biochim. biophys. Acta*, 26: 215–217.

Holley, R. W. 1957. An alanine-dependent, ribonuclease-inhibited conversion of AMP to ATP, and its possible relationship to protein synthesis. *J. Amer. chem. Soc.*, 79: 658–662.

——, and P. Brock. 1958. Intermediates in protein synthesis: Alanine activation and an active ribonucleic acid fraction. *Fed. Proc.*, 17: 244.

Jencks, W. P. 1957. Non-enzymic reactions of acyl adenylate and imidazole. *Biochim. biophys. Acta*, 24: 227–228.

Karasek, M. A., P. Castelfranco, P. R. Krishnaswamy, and A. Meister. 1958. Enzymatic synthesis and reactions of tryptophan-adenylic acid anhydride. *J. Amer. chem. Soc.*, 80: 2335–2336.

Katchalsky, A., and M. Paecht. 1954. Phosphate anhydrides of amino acids. *J. Amer. chem. Soc.*, 76: 6042–6044.

Koningsberger, V. V., Chr. O. Van der Grinten, and J. Th. G. Overbeck. 1957. Possible intermediates in the biosynthesis of proteins. I. Evidence for the presence of nucleotide-bound carboxyl-activated peptides in baker's yeast. *Biochim biophys. Acta*, 26: 483–490.

Koshland, D. E., Jr. 1952. Effect of catalysts on the hydrolysis of acetyl phosphate. Nucleophilic displacement mechanisms in enzymatic reactions. *J. Amer. chem. Soc.*, 74: 2286–2292.

Littlefield, J. W., E. B. Keller, J. Gross, and P. C. Zamecnik. 1955. Studies on cytoplasmic ribonucleoprotein particles from the liver of the rat. *J. biol. Chem.*, 217: 111–123.

Lipmann, F. 1941. Metabolic generation and utilization of phosphate bond energy. *Advanc. Enzymol.*, 1: 99–162.

——. 1958. Chairman's introduction: some facts and problems. *Proc. nat. Acad. Sci. U. S.*, 44: 67.

Michelson, A. M. 1958a. A hypothesis for the biosynthesis of ribonucleic acid and protein. *Nature, Lond.*, 181: 375–377.

——. 1958b. Synthesis of ribonucleic acid. *Nature, Lond.*, 181: 303–304.

Novelli, G. D. 1958. Some problems concerning the activation of amino acids. *Proc. nat. Acad. Sci. U. S.*, 44: 86–92.

Oeengand, E. J., F. H. Bergmann, and P. Berg. 1958. Enzymatic synthesis of an RNA-amino acid complex. *Fed. Proc.*, 17: 284.

Pardee, A. B. 1954. Nucleic acid precursors and protein synthesis. *Proc. nat. Acad. Sci. U. S.*, 40: 263–270.

Potter, J. L., and A. Dounce. 1956. Nucleotide-amino acid complexes in alkaline digests of ribonucleic acid. *J. Amer. chem. Soc.*, 78: 3078–3082.

——, and ——. 1957. Some properties of ribonucleic acids. *Fed. Proc.*, 16: 234.

Raacke, I. D. 1958. On the reaction of hydroxyl-

amine with esters of amino acids. *Biochim. biophys. Acta*, 27: 416.

RABINOVITZ, M., and M. E. OLSON. 1956. Evidence for a ribonucleoprotein intermediate in the synthesis of globin by reticulocytes. *Exp. Cell Res.*, 10: 747–749.

——, and ——. 1957. Transformation of ribonucleoprotein in an acellular preparation from rabbit reticulocytes. *Fed. Proc.*, 16: 235–236.

RATHLEV, T., and T. ROSENBERG. 1956. Non-enzymic formation and rupture of phosphorus to nitrogen linkages in phosphoramido derivatives. *Arch. Biochem. and Biophys.*, 65: 319–339.

SCHWEET, R. S., F. C. BOVARD, E. ALLEN, and E. GLASSMAN. 1958a. The incorporation of amino acids into ribonucleic acid. *Proc. nat. Acad. Sci. U. S.*, 44: 173–177.

——, E. GLASSMAN, and E. ALLEN. 1958b Incorporation of amino acids into RNA. *Fed. Proc.*, 17: 307.

SHIGEURA, H. T., and E. CHARGAFF. 1957. Incorporation of radioactive tracers into ribonucleoprotein particles of rat liver microsomes. *Fed. Proc.*, 16: 246–247.

SIMKIN, J. L., and T. S. WORK. 1957. Incorporation of radioactive amino acids into proteins of the microsome fraction of guinea-pig liver in a cell-free system. *Biochem. J.*, 67: 617–624.

SIMPSON, M. V., J. R. MCLEAN, G. L. COHN, and I. K. BRANDT. 1957. *In vitro* incorporation of leucine-l-C^{14} into the protein of liver mitochondria. *Fed. Proc.*, 16: 249–250.

SPIEGELMAN, S., H. O. HALVORSON, and R. BEN-ISHAI. 1955. Free amino acids and the enzyme-forming mechanism. In *Symposium on Amino Acid Metabolism* (W. D. McElroy and B. Glass, eds.), p. 124. Johns Hopkins Press, Baltimore.

TARVER, H. 1954. Peptide and protein synthesis. In *The Proteins* (H. Neurath and K. Bailey, eds.), Vol. II, Part B, p. 1199. Academic Press, New York.

WAGLE, S. R., R. MEHTA, and B. CONNOR JOHNSON. 1957. Vitamin B12 and protein biosynthesis. III. The B12-complex nature of the incorporation enzyme present in cell supernatant. *Arch. Biochem. and Biophys.*, 72: 241–243; Vitamin B12 and protein biosynthesis. *Fed. Proc.*, 17: 330.

WEBSTER, G. C. 1957. Amino acid incorporation by intact and disrupted ribonucleoprotein particles. *J. biol. Chem.*, 229: 535–546.

WEISS, S. M., G. ACS, and F. LIPMANN. 1958. Reaction of tryptophan with tryptophan-activating enzyme bound acceptor. *Fed. Proc.*, 17: 333.

WIELAND, TH., and G. PFLEIDERER. 1957. Aktivierung von Aminosäuren. *Advanc. Enzymol.*, 19: 235–266.

——, and D. STIMMING. 1953. Die Aufspaltungsweise gemischter Saeure-anhydride mit Hydroxylamin. *Liebigs Ann.*, 579: 97–106.

——, E. BOKELMANN, L. BAUER, H. V. LANG, and H. LAU. 1953. Über Peptidsynthesen. 8. Mitteilung. Bildung von S-haltigen Peptiden durch intramoleculare Wanderung von Aminoacylresten. *Liebigs Ann.*, 583: 129–149.

——, H. V. LANG, and D. LIEBSCH. 1955. Über Peptidsynthesen. 11. Mitteilung. Intramoleculäre Aminoacylwanderung bei Peptiden. *Liebigs Ann.*, 597: 227–234.

ZAMECNIK, P. C., M. L. STEPHENSON, J. F. SCOTT, and M. B. HOAGLAND. 1957. Incorporation of C-14 ATP into soluble RNA isolated from 105,000 × g supernatant of rat liver. *Fed. Proc.*, 16: 275.

ZIOUDROU, C., S. FUJII, and J. S. FRUTON. 1958. Labeling of proteins by isotopic amino acid derivatives. *Proc. nat. Acad. Sci. U. S.*, 44: 439–446.

NEW BIOLOGICAL BOOKS

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EVOLUTION OF THE PHYTOTRON

By KENNETH V. THIMANN

Harvard University

A Review of: THE EXPERIMENTAL CONTROL OF PLANT GROWTH *with Special Reference to the Earhart Plant Research Laboratory at the California Institute of Technology.*

By Frits W. Went and 5 contributors. The Chronica Botanica Company, Waltham; The Ronald Press Company, New York. $8.50. xvii + 343 pp. + 20 tables + 25 pl.; text ill. 1957.

If Claude Bernard had been a botanist he would probably never have uttered his famous remark about the fixity of the internal miliеu as the condition of free life. For plants are such creatures of their environment that in them fixity is replaced by fluctuation, by cycles both inherent and impressed, and by sensitivity to the frequent changes in their external conditions which weather and the seasons impose. Accordingly, this book is devoted to the thesis that if every element of the environment is brought under rigid control, then the growth and development of plants can be precisely and reproducibly determined. From the first air-conditioned greenhouses, constructed in Pasadena in 1938, Went conceived the idea of a large laboratory in which a number of environmental variables could be separately controlled. The present Earhart Laboratory, opened in 1949, makes it possible to study the influences of day and night length, day and night temperatures, light intensity, humidity, wind velocity, water and nutrient supply—most of these as independent variables. In emulation of the laboratory, a still larger one is now being built in the suburbs of Paris, a small one is in operation at Liège in Belgium, and a third is being actively planned for erection in Australia. This kind of environmental study is obviously of considerable value for many purposes, both theoretical and practical, and is giving a great stimulus to experimental ecology.

The book itself is divided into three parts. The first deals with the construction and operation of the Earhart Laboratory. A good part of this deals with the details of actual operation and would be mainly of interest to those planning to operate a similar laboratory. There is an interesting discussion of the problems of controlling temperature in a greenhouse, which makes it clear that the main difficulty in cooling a greenhouse during a sunny day is the very large volume of air required; a greenhouse 30 x 90 feet needs at least 1800 cubic feet of air per minute blown through it to prevent the temperature from rising more than 10°C. Such large volumes are difficult to supply through ducts without causing powerful draughts and uneven air distribution; for this reason Went—and also Bouillenne at Liège—adopted slotted floors through which the air rises evenly all over the house. As a matter of fact, most workers in northern latitudes find artificially lighted growth chambers more convenient than greenhouses, since the light intensity is constant not only throughout the daily light period but also from month to month and from season to season. However, the light intensity in such chambers is not easily raised above one-fifth the level of noon June sunlight.

A troublesome problem both with air-conditioned greenhouses and with artificial growth chambers is the control of insect and fungus pests. In the writer's experience red spider and downy mildew have been very troublesome. Went mentions the same organisms, as well as aphids and certain viruses. However, a very elaborate system of de-

contamination for workers in the laboratory as well as sterilization of plants, seeds, sand and gravel, has been adopted at the Earhart Laboratory. Soil is not used at all, and almost everything else brought in is fumigated with methyl bromide.

Part II describes the climatic responses of individual plants, mostly cultivated types, with additional chapters on the broad bean by Lloyd Evans, grasses by W. M. Hiesey, and chaparral plants by Henry Hellmers. This section is full of interesting lore about plants, and the data are of course the major justification for the whole project. We read, for instance, that low humidity of the air has little detectable effect on most plants (tomatoes are an exception); the typical habit of desert plants is not a response to low humidity but to cool nights. The Joshua tree, *Yucca brevifolia*, grows poorly at altitudes below about 800 meters because, apparently, after it is 3 to 4 years old it requires an annual cold period for normal leaf development. This is a nice, clear example of the applicability of a controlled-environment laboratory to ecological problems. On some of the crop plants like peas, beans, and tomatoes the temperature relations are too extensive and complex, and differ too much from one variety to another, to be summarized briefly, but it is evident that the data can be of great value to commercial growers. Later on in the book it is shown, as an additional complication, that "in most plants the optimal temperature gradually decreases as the plant grows older." Perhaps because of all these complications in temperature-dependence, W. M. Hiesey, from his discussion of the effects of both genetic and environmental factors on the growth of numerous grass species, concludes that "critical investigations under controlled conditions can scarcely be said to have begun," and this is doubtless true of other economic plants.

In the third part, devoted to General Discussion, Went discusses the results of these and other experiments, together with a number of other minor studies which had not been included under Climatic Response, and with the addition of two very short chapters contributed by W. C. Ashby and A. W. Galston respectively.

In such a mass of information it is perhaps picayune to take exception to three odd conclusions. The influence of rain before germination on the subsequent growth of the seedling is ascribed to "induction . . . comparable with vernalization" but I see no compelling reason to suppose it is anything but the water remaining in the soil. Secondly, in analyzing the auxin relations of tomato plants, Went had earlier concluded that there was no relation between growth rate and auxin content, and since the application of auxin to intact plants seldom accelerates growth, he now says that "the function of auxin in the tomato stem [is] mainly in relation to geotropic and phototropic responses, and not as an absolute limiting factor." But if auxin were not a limiting factor for growth, how could a slight redistribution of it due to the stimulus of gravity or light (commonly 70% on the lower or shaded side instead of 50%) immediately cause a curvature? Thirdly, Went has assembled considerable evidence to support the view that translocation in the phloem *increases* with *decreasing* temperature. If physical flow is a controlling factor in the sieve-tubes, one could perhaps imagine that translocation might be fairly insensitive to temperature, but I think that most physiologists will find it hard to believe that it should vary inversely with temperature, especially at temperatures from 30°C downwards. Perhaps the amount of solute left, after enzymes have removed part of it from the phloem, increases with decreasing temperature and this might explain Went's observations.

It is curious that in all the work on temperature, only a couple of paragraphs are devoted to the temperatures of the roots. When the air temperature is suddenly changed by 6°C or so, as, for instance, in the frequently-used regime 23°C day temperature 17°C night temperature, how closely does the root system follow this? The larger the container, the more, it seems, the root temperature must lag behind; the water content of the medium (because of its high heat capacity) must exercise an important role, too. Went believes that the soil temperature only controls plant growth "when the root system is small, restricted, or poorly aerated." One cannot help wondering, however, what factor it is that delays the onset of growth of shrubs and trees in the New England spring, when often the air temperatures should be favorable for growth, but no growth occurs. At the other extreme, reasons are given for believing that in the California desert on a sunny day soil temperatures may reach 70°C in the upper layers; could these be without effect on the root system? Doubtless these and other problems are for the future.

The closing chapter, which is a claim for the importance of the work and of the laboratory, was really not necessary. "Time is the best appreciator of scientific work," Pasteur once said, and the old man carries not only a scythe but also a stock of laurels. Perhaps the author had a donor, trustee, or other interested party in mind when he wrote this section.

All in all, this is a stimulating and very readable book with a great deal of original thought in it throughout, and it describes a contribution of the first importance to several branches of plant science.

REVIEWS AND BRIEF NOTICES

General Biology: Philosophy and Education ... 264
Ecology and Natural History ... 267
Evolution ... 268
Genetics and Cytology ... 269
General and Systematic Botany ... 271
Plant Morphology and Development ... 278
Plant Physiology ... 279
Economic Botany ... 279
General and Systematic Zoology ... 281
Economic Zoology ... 283
Animal Growth and Development ... 284
Animal Morphology ... 287
Animal Physiology ... 288
Biophysics and General Physiology ... 288
Biochemistry ... 290
Microbiology ... 292
Health and Disease ... 293
Psychology and Animal Behavior ... 297
Human Biology ... 298
Biometry ... 299
De Omnibus Rebus et Quibusdam Aliis ... 299

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

A Modern Introduction to Philosophy. *Readings from Classical and Contemporary Sources. Edited by Paul Edwards and Arthur Pap. The Free Press, Glencoe.* $6.50. ix + 648 pp. 1957.

Eventually, some malcontent student of philosophy is going to produce a Ph.D. thesis on the rhetoric of introductions to philosophy. The offspring of this labor will, of course, be buried at its own birth, but somehow the cosmos will have become better for its having existed. One of the salient facts our burgeoning philosopher will discover is that the contemporary American philosopher is typically imbued with a notable historical and cultural provincialism.

Hence it is that from the larger view, this volume might have been more appropriately titled "An Introduction to Some Contemporary British and American Philosophical Outlooks," for the vast majority of its selections are taken from 20th century writings by academic British and American philosophers. Greek thought is represented by an extract from one Platonic dialogue, and the medieval period is given status by a few pages from Thomas Aquinas, but other than these two selections, the reader (presumably a beginning student), is given no real intimation of Greek, Roman, medieval, or Renaissance thought. Is one to conclude that to be modern is to lose, or avoid the very possibility of, historical perspective?

The isolationism of this text is not merely historical, however, for contemporary European existentialism is utterly ignored; not even the names of Heidigger, Sartre, or Marcel appear in the text, and Jaspers is only mentioned in an aside. Indeed, the whole collection of writings suggests an acute linguistic isolation; there is included only one selection from any continental European source since Kant. Is the naive reader to conclude that 19th and 20th century Europe have been almost devoid of any philosophic thought worth mentioning, other than that which has been expressed better by English-speaking philosophers (e.g., logical positivists)? This is hardly the case.

Ultimately, for all the attempt to present all sides of each philosophical problem discussed, this is a text in which, in both the introductions and the selections, the evidence is slanted in favor of a modern empiricism. Furthermore, this introduction will not be satisfactory for either the potential scientist, whose interest in philosophy will typically center about logic and methodology, nor for the humanist, who will be seeking for an insight into the history of ideas or the history of philosophical concepts.

Few books are without some merits, however, and this one will serve certain purposes. For all its failings as an introduction to philosophy as a whole, the work is an excellent introduction to the present state of certain schools of philosophy in America and Great Britain, although a little broader in scope than this. Perhaps the most interesting selection is comprised of a hitherto unpublished radio debate originally conducted on the Third Program of the B.B.C. between A. J. Ayer and F. C. Copleston on the subject of logical positivism. To sum up: within its narrow scope, this is not a book without interest, but it will scarcely serve the purpose its authors apparently intended.

James J. Hill

Minnesota Studies in the Philosophy of Science. *Volume I. The Foundations of Science and the Concepts of Psychology and Psychoanalysis. Edited by Herbert Feigl and Michael Scriven. University of Minnesota Press, Minneapolis.* $5.00. xiv + 346 pp. 1956.

All but one of the papers contained in this volume have grown out of discussions held at the Minnesota Center for the Philosophy of Science, founded in 1953, or at least were modified by such discussions. Feigl points out, in the Preface, that there are some significant disagreements among the ten contributors, and nevertheless a common ground or core of opinion, for example, in regard to "the meaning of theoretical concepts as defined by their

locus in the 'nomological net,' and the related rejection of the reductionist forms of operationism and positivism." The theoretical view adopted is that of logical empiricism.

The contributions are as follows: Some major issues and developments in the philosophy of science of logical empiricism (H. Feigl); The methodological character of theoretical concepts (Rudolf Carnap); Critique of psychoanalytic concepts and theories (B. F. Skinner); A study of radical behaviorism (M. Scriven); An operational reformulation of some of the basic principles of psychoanalysis (Albert Ellis); Motives and the Unconscious (Antony Flew); Construct validity in psychological tests (L. J. Cronbach and P. E. Meehl); Problems in the actuarial characterization of a person (P. E. Meehl); On the logic of general behavior systems (R. C. Buck); The concept of emergence (P. E. Meehl and Wilfrid Sellars); Empiricism and the Philosophy of Mind (W. Sellars); and A possible distinction between traditional scientific disciplines and the study of human behavior (M. Scriven).

SCIENCE AND THE CREATIVE SPIRIT. *Essays on Humanistic Aspects of Science.*

By Karl W. Deutsch, F. E. L. Priestley, Harcourt Brown, and David Hawkins. University of Toronto Press, Toronto. $4.50. xxvii + 165 pp. 1958.

This volume is a collection of 4 essays prepared by the Committee on the Humanistic Aspects of Science of the American Council of Learned Societies. This Committee, according to the foreword by D. H. Daugherty, included more members than the 4 authors who contributed essays to the book; while the named authors chose and developed their own subjects, each of the essays was repeatedly circulated among and discussed by the larger group, so that "each essay is in a most real sense the work of the entire committee."

The book begins with a 19-page statement, an essay in itself, on Why This Book was Written, by Harcourt Brown, Chairman of the Committee and editor of the volume. The subtitle gives the clue. The group seeks to focus its thought upon the humanistic aspects of science in recognition of the fact that while differences exist between science and the humanities, a border zone lies between them whose exploration may reduce the area of disagreement between the denizens of the two domains.

Each essay begins with an individual attempt to formulate the nature and aims of science and of the humanities, and then proceeds to discuss a particular aspect of the borderline field. Karl Deutsch first takes up the place of accumulative knowledge in the sciences and humanities, and next, problems of scale: time, size, and number. When he moves on to qualitative aspects of science, he deals with such issues as rationality, intuition, and values, of the resources common to the sciences and humanities, and with what he calls the "constraints" between them. F. E. L. Priestley examines selected aspects of the history of English literature, from the 17th century until the present, in order to illustrate the conditions under which science enriches literature by becoming a valuable source of material for the poet. Harcourt Brown considers the interplay between science and the humanities in their emergence in French civilization during the same period. The volume concludes with an essay by David Hawkins which, from the philosophical point of view, deals with some of the human and creative characters of science. Like that of his colleagues, his approach is historical, and it is surely of some significance that the authors all analyze their problems in historical terms.

These essays do not purport to answer questions, but to ask them. They are all thoughtful, and all written well. Their subjects are of moment to us all, and it is to be hoped that they will receive the attention they deserve.

JANE OPPENHEIMER

SCIENCE: HOW? WHY? WHEREFORE?

By Edward M. Robinson and George T. Polk. The Priory Press, Dubuque. $1.95 (paper). xvii + 244 pp. 1957.

This is a volume designed to stimulate an interest in science, particularly among young people of the high school senior and college freshman level. It was designed for either independent reading or use as an accessory text to one or more science courses. If its title gives small clue to its contents, it would be difficult to find another which would serve better, for the variety of subject matter the book embraces perhaps defies an adequate title.

In a sense, this small work is an anomaly in its genre, and it is this anomalousness which makes it so interesting. Not only is it an introduction to some of the data and methodologies of modern physics and biology, but it is also an attempt to show, on an introductory level, the relationship of these data and methodologies to a Neo-Scholastic philosophy. Whether the authors have or have not succeeded in adequately presenting an integration of modern science with a realistic metaphysics is something the prospective user of this text may want to discover for himself; although the more positivistically minded scientist will perhaps consider many of the theses of the book irrelevant to his own activities. For biologists interested in a philosophical approach to their discipline, however, the bio-

philosophical analysis of the nature of growth presented in this text may prove to be of some interest, even though it was not intended for a very sophisticated reader.

This volume bears the imprimatur of the late Cardinal Stritch. If the book serves to promote an interest in science, particularly among those more naive religionists in whose minds a confusion between science and what some scientists say tends to breed insecurity, it will have served a useful function.

JAMES J. HILL

THE SCIENCE TEACHER IN ACTION.

By Helen Lawrence Merrill. Christopher Publishing House, Boston. $2.25. 84 pp. 1956.

This is a small book devoted to the secondary school teacher of science and his role in providing the kind of educational atmosphere which is best suited to the various types of students which any teacher finds in his classroom. While it could not be termed a "methods" book, it does give a kind of general guidance which any new teacher of science would find helpful.

Mrs. Merrill has chosen to highlight the manifold tasks of the teacher in a number of short chapters, each of which illustrates a representative problem. The reactions of a small group of students, identified by name and characterized, to a number of classroom situations serve as case histories. A post-graduation follow-up on each student serves in a sense to validate the conclusions drawn from the educational experience.

This book makes a number of good points which are as relevant to the teaching of science in college as in high school. The author vigorously opposes the interest-deadening cookbook approach to laboratory experiments, the stifling of natural curiosity by failing to provide proper opportunities for students, and the emphasis on (for teenagers almost invariably dry) facts to be memorized rather than concentration on the fundamental concepts which underlie the science and are their own best generators of scientific interest. Narrow vocationalism, which is developed in many schools to a very high degree, is decried in favor of more basic courses of study which, in the end, result in a better educated and more adaptable person.

While this book, which no doubt is based on years of personal experience, serves a genuine need, unfortunately the writing is uneven and the rhetoric only fair. Yet it must be said that the volume preceded the era of critical reexamination of our science teaching programs, and truly focuses on some of the problems which subsequently have been identified as worthy of our most diligent and continuing scrutiny.

FRANK C. ERK

CHANGING VALUES IN COLLEGE. *An Exploratory Study of the Impact of College Teaching.*

By Philip E. Jacob. Harper & Brothers, New York. $3.50. xvi + 174 pp. 1957.

College educators have apparently been deluding themselves about the effectiveness of their curricula in influencing student values and beliefs. Curiously, Jacob and his colleagues express surprise over their findings, which seem obviously to be expected. The study reported in this book was conducted under the auspices of the Edward W. Hazen Foundation in an effort to determine the impact of social science education in changing the values of college students. In effect, the research has also delineated the influence of other areas in general education in the same respect. The general conclusions drawn from the collected data support the contention that changes in student values cannot be attributed either to the general curriculum or to basic courses in social science. There is no significant difference between the values expressed by students interested in social science and those by students interested in other fields. A very disheartening aspect of the data is that the good teacher has no more effect on the values held by a student than does the poor teacher!

All of this does not mean that student values do not change in the course of a college education, nor that curricula or teachers have no influence. The conclusions are based on majority responses, but some students are liable to value changes as the result of certain courses and particular teachers. The major change is a process of liberalizing: students tend to be less rigid in their beliefs after exposure to the college community. Yet the acquisition of factual information has little influence on student attitudes about such things as racial and ethnic prejudices and other such emotionally oriented thinking. An especially enlightening feature of the study involves the effect of the particular institution on student attitudes. An institution has about it a distinctive tone which sets the style of student thought and behavior. This aspect requires further investigation, and is included in studies proposed for future research. Although the data collected to date have indicated little influence of curricula on changing student values (a predictable conclusion), the study is useful if only in awakening or reminding educators of the true value of their efforts. It is also noteworthy in showing what direction such studies must now follow.

NORMAN S. COHN

THE FOUNDATIONS OF SCIENCE.

By Sheldon J. Lachman. The Hamilton Press, Detroit. $1.50 (paper). 130 pp. 1956.

What is natural science? It is interesting that philosophers and scientists themselves have somewhat different conceptions of the matter. Scientists learn their trade in the graduate schools largely through imitation of their preceptors, largely through trial and error. Not many of them ever sit down to think hard about the logic they employ, the nature of proof, the fundamental assumptions they make, or the relation of scientific method to empiricism, operationalism, or other philosophies. Once in a while a young scientist reads a book like W. K. Clifford's *Common Sense of the Exact Sciences*, Karl Pearson's *Grammar of Science*, or J. Arthur Thomson's *Introduction to Science*, and experiences an awakening. Modern books of that sort are all too few; nor is the present little paperback one of them. It is a formal statement, for the most part sticking to truisms, and completely lacking any quality likely to stimulate either thought or activity. One sample of its style should be sufficient:

> The scientist holds that matter is real, i.e., that matter exists in time and space. By matter is meant substance, i.e., tangible, discernible, palpable material. The material objects which exist in time and space, possess dimensionality and may be described in part by indicating the coordinates of spatial dimensions in which they exist.

ECOLOGY AND NATURAL HISTORY

PRINCIPLES OF FIELD BIOLOGY AND ECOLOGY.

By Allen H. Benton and William E. Werner, Jr. McGraw-Hill Book Company, New York, Toronto, and London. $6.50. vii + 341 pp.; ill. 1958.

This book provides an introduction to American field biology, or, in other words, ecology with a strong leaning toward animal ecology and the basic requirements for conservation and wildlife management, with so-called economic field biology as a particularly essential point. It is an exemplary introduction into these fields and can be recommended to those interested in population dynamics, irrespective of interest in how the animals or plants can be utilized. Although the chapters on plant succession are short, they are informative and might be especially useful for non-biologists and engineers engaged in works affecting the vegetation of large areas. As a whole, the book is reasonable and gives clear information about general ecological principles, and the only background needed for its understanding is an interest in the subject.

The authors claim that the book is taxonomically oriented, and this is true for most of its zoological part. As to the botanical part, however, this is an overstatement, as can be seen most easily in the chapters on nomenclatural codes and in the legends to some of the pictures; it will, at the very least, be difficult for a botanist to find the cattails said to dominate in Fig. 6–16, since these seem to be properly hidden behind an unrelated grass! A remark on the quality of the pictures may also apply to other textbooks of recent years, since it is apparent that many of these have been reproduced from Kodachromes. It does not matter how sharp and good the color-pictures are, when reproduced in black and white they almost invariably lose in sharpness and clarity, and no such pictures should be accepted where exactness is essential. It is better not to have any pictures at all, since inferior ones do nothing but fill space and irritate the reader.

Amateurs and zoology students will enjoy the last chapters of the book, which give information on how to find and use biological references, how to select and conduct a field problem, and how to write about the results, although the recommendations as to the last subject are not to be followed if the report is meant to become interesting and readable. The glossary and appendix are good sources of reliable information of interest to many.

ÁSKELL LÖVE

CALIFORNIA AND THE SOUTHWEST.

Edited by Clifford M. Zierer; 32 contributors. John Wiley & Sons, New York; Chapman & Hall, London. $11.25. x + 376 pp.; ill. 1956.

This regional geography, under the headings of Agricultural Activities and Other Kinds of Resource Use, devotes some attention to land use, the fruit and nut industry, field crop production, vegetable crop production, the livestock industry, forests, forests industries, and forest problems, and marine fisheries. Under the Physical (sic) Characteristics of the Region one finds vegetation and animal life, treated ecologically as well as descriptively. The brevity of the attention to biological aspects of the region will make this work useful as a biological reference work only to those who desire a cursory survey or who want gross statistics on production.

AN EVENING IN SAPSUCKER WOODS. *The Songs of Birds and Other Denizens of a Northeastern Woodland. 33⅓ RPM.*

Cornell University Records, Ithaca. $4.95. 1958.

Those who are acquainted with the other fine recordings by the Laboratory of Ornithology of Cornell University will not meet with unfamiliar songs

on this 10-inch record. Instead, novelty takes the form of a restriction to the birds of a particular environment, the Sapsucker Woods surrounding the Laboratory at Cornell. On Side One Arthur A. Allen identifies 32 voices, including 5 toads and frogs. On Side Two the voices are unidentified, and include many not specifically named on Side One. Here is a real challenge for the bird-listener! Especially appealing is the arrangement of the recording to represent passage from afternoon into evening and night. It requires little imagination to see the shadows lengthening over the pond as the water birds succeed the earlier singers, until finally the chorus of toads, frogs, and peepers sets in for the night, to be broken spasmodically by the hoot of an owl. ..

On a powerful high fidelity set one still has trouble with these recordings because of the resonance and over-amplification of the parabolic reflector used in the recording. This is particularly noticeable when an effort has been made to bring the listener right to the spot where one of the less strong-voiced singers is carolling. Best results have been obtained in the more natural recordings of distant, strong-voiced cries and calls which the listener to the record can amplify to suit himself.

BENTLEY GLASS

VOICES OF AFRICAN BIRDS. *Songs and calls of 42 species found in Kenya, Uganda, Sudan, Tanganyika, Rhodesia, South Africa, the Congo, and Nigeria.*

Recorded by Myles E. W. North; introduction by A. A. Allen. *Cornell University Records, Ithaca.* $7.75. 1958.

This 12-inch, two-sided, long-playing record is intended to give the listener an interesting selection of representative African birds. The vocalisms of 42 species are presented, recorded chiefly in Kenya Colony, including such diverse sorts as the crowned crane, ground hornbill, go-away bird, sand grouse, red and yellow barbet, greater honey-guide, boubou shrike, bulbul, nightingale, fan-tailed raven, and superb starling. The recorder has described each song on the record, and points out that the time intervals between the recorded song-phases have had to be shortened in order to economize space on the record, and that this one aspect of the performance is not wholly accurate. Otherwise the sounds are true to life and are remarkably free, in most cases, from extraneous background noises.

HERBERT FRIEDMANN

EVOLUTION

THE SPECIES PROBLEM. *Symposium presented at the Atlanta Meeting of the A.A.A.S., Dec. 28–29, 1955.*

Edited by E. Mayr. *American Association for the Advancement of Science, Washington, D.C.* $8.75. ix + 395 pp.; ill. 1957.

The authors of the papers in this symposium attempt to define the species concept best suited for general usage, and to point out some of the difficulties in applying it. The introduction by Mayr discusses the three species concepts in general use today: the typological or morphological species, the genetic or non-dimensional species, and the biological species. Most of the other participants in the symposium seem to agree that the concept of a biological species (defined as a group of reproductively isolated, interbreeding natural populations) has widest applicability. H. L. Carson considers sexually reproducing animals and discusses the species as a gene pool. The type of reproduction of a species can be related to the past history of the species, its present variability, and its potentiality for future evolutionary change. In his discussion, organisms which do not undergo sexual reproduction are considered as an evolutionary "dead end." This idea is at variance with the views expressed on speciation in plants in the following paper by Verne Grant, who feels that biological species do not exist in asexual groups, but that the latter are not necessarily evolutionary dead ends. Grant points out the fact that introgression plays a much larger part in complicating the distinguishing of species in plants than it does in animals, though all major groups of plants contain discrete species. He suggests the recognition of a *syngameon* (hybridizing population of species or subspecies) to clarify a situation involving introgression. Two cases of introgression in freshwater animals are discussed by J. L. Brooks, who feels that the extreme phenotypic variability of freshwater species is partly due to the environmental extremes which they experience and partly due to introgression between coexisting species. An extensive review of the taxonomic problems in the Protozoa is given by Sonneborn, who emphasizes the difficulty of determining protozoan species. As an alternative to the biological species concept, he proposes the term *syngen* to designate a group of organisms with a common genetic pool. For asexual Protozoa with no common gene pool there would, then, be no biological species. The papers by J. A. Moore and C. L. Prosser discuss the development of isolating mechanisms arising as adaptive responses, becoming genetically established, and finally resulting in reproductive isolation and speciation. J. Imbrie discusses the problems of applying the biological species concept to fossil material.

In summarizing the conclusions of the symposium,

Mayr returns to the dualistic species concept as the most practical for general application. Sexually reproducing organisms are to be considered as biological species, while asexually reproducing organisms must still be described as morphological species.

MARGARET FOREMAN COHN

TREATISE ON INVERTEBRATE PALEONTOLOGY. PART F, COELENTERATA.

Directed and Edited by Raymond C. Moore; 10 Contributors. Geological Society of America, New York; University of Kansas Press, Lawrence. $7.00. xx + 498 pp.; ill. 1956.

As successive volumes of this great *Treatise* appear from the press, it is amply evident that this will remain for many decades one of the great reference works of natural science. The participation of the world's leading living authorities in the work, and the very excellent editorial attention it has received, are sufficient to guarantee its preeminence. The abundant illustrations, whether diagrams or reproduced photographs, are outstanding. This is the sixth of the projected 22 volumes.

The sections of this volume are as follows: Introduction; Cnidaria—General Features; Morphology of Living Coelenterates; Protomedusae; Dipleurozoa; Scyphozoa; Hydrozoa; Medusae Incertae Sedis and Unrecognizable Forms; Anthozoa; Ctenophora; Index.

MINIOCHOERINAE AND OREONETINAE, TWO NEW SUBFAMILIES OF OREODONTS. *Bull. Amer. Mus. nat. Hist., Vol. 109, Art. 4.*

By C. Bertrand Schultz and Charles H. Falkenbach. American Museum of Natural History, New York. $1.50 (paper). Pp. 373–482; ill. 1956.

This publication, from the paleontologists of the Frick Laboratory (American Museum of Natural History) and the University of Nebraska State Museum, constitutes the seventh contribution to the revision of the oreodonts. Under the Miniochoerinae 4 new genera, 2 new subgenera, and 15 new species are described; under the Oreonetinae, 1 new subspecies. These primitive ruminants are all from the Oligocene White River formations. The Miniochoerinae includes forms of small to medium size (largest mean skull length 16.1 cm.), while the Oreonetinae embraces the smallest oreodonts known (basal length of skull in *Bathygenys alpha* ca. 7.0 cm.).

AMERICAN *Hyracotherium* (PERISSODACTYLA, EQUIDAE). *Bull. Amer. Mus. nat. Hist., Vol. 110, Art. 1.*

By David B. Kitts. American Museum of Natural History, New York. $1.00 (paper). 60 pp. + 7 pl.; text ill. 1956.

EARLY DEVONIAN FISHES FROM UTAH. *Part III. Arthrodira. Fieldiana: Geol., Vol. 11, No. 9.*

By Robert H. Denison. Chicago Natural History Museum, Chicago. $2.50 (paper). ii + pp. 461–551; ill. 1958.

GENETICS AND CYTOLOGY

METHODS OF PLANT BREEDING.

Edited by Herber Kendall Hayes. McGraw-Hill Book Company, New York, London and Toronto. $8.50. xi + 551 pp.; ill. 1955.

One is sometimes tempted to believe that American plant breeders have fallen behind their European contemporaries in the production of books and other general publications in their chosen field. Excellent as *Methods of Plant Breeding* is, it can hardly substitute for the encyclopedic *Handbuch der Pflanzenzüchtung* by Th. Roemer and W. Rudorf. Moreover, Americans have no plant breeding journal such as the Dutch *Euphytica* or the German *Der Züchter*. Additional similar comparisons might be made.

Fortunately for breeders working with horticultural materials, general considerations are emphasized in the volume under review. Such subjects as heterosis, modes of reproduction, pure-line method and hybridization, back-crossing, and breeding for resistance occupy well over the first third of the book. After a discussion of the breeding of the leading agronomic crop plants, almost a final third of the volume considers problems of measurement, statistical methods, field-plot technique, and experimental design. There is a final chapter on heritability.

Of special interest is the summary on agronomic, horticultural, and specialty crop plants grouped according to Vavilov's 8 principal regions of origin, and a table giving the chromosome numbers of most of the fruits and crop plants, including the vegetables cultivated in America. In the discussion of techniques of pollination the horticulturist might desire information on the degree of natural self- and cross-pollination and on distances required for satisfactory isolation for seed increases, especially of vegetables. The chapters on hybridization and backcross methods and the two chapters on breeding for disease and insect resistance have especially wide usefulness for breeders generally. Inheritance and linkage in maize receive a gratifying degree of attention. The 6 chapters (68 pages) devoted to

statistical methods contain an amazing amount of information.

It is by no means surprising that no mention is made of genetics and breeding of any of the vast number of ornamentals or forest trees. The accomplishments and usefulness of this book emphasize the need for similar publications in the field of floriculture and perhaps forestry. When these appear, a more restrictive title might be considered for the present work.

S. H. YARNELL.

AN INTRODUCTION TO GENETIC STATISTICS. *By Oscar Kempthorne. John Wiley & Sons, New York; Chapman & Hall, London.* $12.75. xvii + 545 pp.; ill. 1957.

During the past twenty years, techniques of statistical analysis for genetical data have proliferated to such an extent and with such specialization as to develop a real danger that genetical statistics may become divorced from the mainstream of statistical thought, a mystery to be practised with great skill by a few initiates but eventually suffering from lack of fertilization with new ideas from general statistical and biometric theory. It would indeed be tragic for genetics and statistics alike if the fate of psychometric factor analysis were to befall the statistical techniques for the analysis of quantitative inheritance. Kempthorne deserves great credit for his efforts to counter this trend. In his book he has not only presented a systematic account of basic methods for the geneticist, but has also shown both how these arise from central statistical theory and how genetical problems suggest questions that can properly interest the mathematical statistician.

Although the reader who takes up the book is likely to have some acquaintance with biometric statistics, this is not required of him; indeed, the book is itself an excellent introduction to some aspects of statistics, since Kempthorne has incorporated elementary discussions of probability, the basic distributions, hypothesis testing, estimation, analysis of variance, and other topics amply illustrated from genetical problems. Inevitably the algebra required is sometimes heavy, but the reader who lacks knowledge of advanced mathematics will encounter very little that is beyond him.

From the simple arithmetic of Mendelian inheritance, Kempthorne develops his book along three main lines, the analysis of breeding systems in respect of genotypes at one or two loci, the stochastic theory of genetic populations, and the study of inheritance of quantitative characters. He acknowledges a debt to R. A. Fisher's pioneering work in all these fields, but especially to his 1918 paper, "On the correlation between relatives." To the theory of quantitative inheritance in particular, Kempthorne has himself made notable contributions; naturally this theory forms a major part of the book in which he presents a well-integrated and comprehensive account including multilocal and polyallelic systems, with some discussion of complications caused by epistasy, linkage, and polyploidy. Kempthorne may have conceived his book as a text for students; yet many who have long left their days of formal study will welcome this opportunity to gain knowledge of how statistical thought today illumines our understanding of inheritance.

DAVID J. FINNEY

OLIGOPHRENIA IN COMBINATION WITH CONGENITAL ICHTHYOSIS AND SPASTIC DISORDERS. *A Clinical and Genetic Study. Acta psychiat. scand., Suppl. 113, Vol. 32.*

By Torsten Sjögren and Tage Larsson; with assistance of Göta Petersson. Ejnar Munksgaard, Copenhagen. 25 Sw. Cr. (paper). 112 pp. + 1 pl. + 1 folding chart; text ill. 1957.

This thorough study of a syndrome combining oligophrenia, congenital ichthyosis, and spastic disorders represents, like other Scandinavian studies in human genetics, an important medical contribution. The condition, dependent upon an autosomal recessive gene mutation, has not been previously described. The material studied included 29 cases of ichthyosis, of which 24 patients also showed a low-grade oligophrenia and spastic disorder with the symptoms characteristic of Little's disease. The congenital ichthyosis was pronounced and extensive. Seventeen of the affected individuals either could not walk or did so only with support, whereas six others displayed a marked spasticity of gait. Two cases underwent a thorough biochemical and serologic examination; no significant departures from normal were found. The phenylpyruvic acid test was among the negative tests. The thyroid gland and primary and secondary sex characters were normal. An ophthalmological examination of three cases showed reduced vision and degeneration in the pigmented epithelium of the macula. The mental status of the patients varied from idiocy (I.Q. up to 30) to marked imbecility (I.Q. up to 50).

Except for three patients, the normal parents of affected persons were born in the County of Västerbotten in the north of Sweden. Genealogical search in the church registers traced ancestors of the patients to a restricted area in the northeast part of the county. Consanguinity was established in 8 of 13 families. The autosomal recessive mutation responsible for the syndrome probably occurred more

than 600 years ago. The mutation was spread in normal-appearing heterozygotes by chance and also because of the rapid increase in population in this area. It is estimated that now about 3,000 persons, or 1.3%, of the population of Västerbotten County are heterozygous for this mutant. To those who are unconcerned about increasing our exposure to the mutagenic effects of radiation, this study should demonstrate how a rare mutation can become so spread in the population that in time (600 years) homozygotes can occur in appreciable numbers without *close* kinship on the part of their parents. Although none of the detailed biochemical tests was positive, it is to be hoped that the case material and this excellent monograph will prove a stimulus for future biochemical studies to discover the cause of this profound metabolic disorder.

SARAH B. PIPKIN

GENERAL CYTOCHEMICAL METHODS. *Volume I. Edited by J. F. Danielli. Academic Press, New York.* $12.80. xii + 471 pp.; ill. 1958.

This book is the first of a series which should appear at intervals of about two years. It is possible that this series will fill a much needed position in the newly emerging and crystallizing body of knowledge referred to as cytochemistry. It will allow specialists in certain areas of cytochemistry to present their methodology in detail and should serve as a reference source for the methodology dealing with a particular class of procedures up to the date of publication. In looking over the list of contributors, one notes particularly that those authors concerned with physical methods have rather recently described methods in other similar, if not quite so detailed, articles, e.g., Engström, Davies, Walker, and Pelc have contributed similar material to the symposium on *Cytochemical Methods with Quantitative Aims* (also reviewed in this issue of *Q.R.B.*). Some of these authors have likewise published extensively on methods elsewhere during the last two years. The contributions on physical methods are: dry mass determinations with soft x-ray (Engström and Lindström); dry mass determination with interference microscopy (Davies); UV-microspectrophotometry (Walker); DNA determination by microspectrophotometry after Feulgen staining (Leuchtenberger); and autoradiography as a cytochemical method with respect to C^{14} and S^{35} (Pelc). All these seem to be quite complete and much more extensive than other recent articles by the same authors. In all of them, recent considerations with respect to technique and instrumentation are introduced.

The more chemically oriented contributions are also welcome. The mercury orange method for protein-bound —SH determination (Bennett and Watts) appears to be a reliable quantitative method and may remove some of the paradoxes observed in earlier work on protein-bound —SH groups. The authors might have been a bit clearer in their technical directions for the actual use of this method in cytochemistry. The indigogenic methods of Holt for esterases appear to give simple, rapid, and reproducible results, with particularly fine intracellular resolution in the case of 5-bromo-4-chloroindoxyl. The fact that each of the substrates must be synthesized must constitute a possible stumbling block to general application of these methods at this time. Coons describes the details of his fluorescent antibody method, together with a summary of its uses to date. Danielli concludes with a consideration of the calcium phosphate precipitation method for alkaline phosphatases. The theory of the method, the best practices, and a suggestion for quantitation using interference microscopy on such sections, were presented.

RONALD R. COWDEN

GENERAL AND SYSTEMATIC BOTANY

PLANT CLASSIFICATION. *By Lyman Benson; principal plant dissections and illustrations by Jerome D. Laudermilk. D. C. Heath & Company, Boston.* $9.00. xiv + 688 pp.; ill. 1957.

The main interest of European taxonomists seems to be in publishing splendid floras rather than thick textbooks in their subjects. There is hardly a country east of the Atlantic so small that it does not have a modern manual of its plants, and some of the most magnificent handbooks printed have been or are being published somewhere in Europe. Enviable examples: the Flora SSSR, the Rumanian Flora, the British Flora, the Hungarian Flora, etc., not to forget the planned European Flora. Very few textbooks in taxonomy, however, are published in Europe, and the few good ones available in the major languages are used in many countries. In North America, however, the interest in floristics is very low, only a few states and provinces having reasonably modern manuals, and nobody knows what plants are met with on the continent as a whole, since no general North American Flora is available. Instead, textbooks in taxonomy with the claim to be elementary are frequently published, though apparently without adding much to the interest in this fundamental subject. The few European textbooks are perhaps less luxuriously illustrated and are printed on cheaper paper, but they inform the reader less about the personal opinions and beliefs of the

writer and more about the real principles of the subject and how its methods are applied. Moreover, although considerably more time is allowed for the subject at European universities, the elementary textbooks are smaller and less expensive than their American counterparts, and are made in such a way as to increase the interest of the student in looking up different details and controversial matters of arrangement of families and orders. They are also based on good floristic knowledge of the readers, especially at the species level.

Perhaps the most commendable of these recently published elementary textbooks from Europe is that by W. Rothmaler: *Allgemeine Taxonomie und Chorologie der Pflanzen*, which, in a little more than 200 pages, informs the student about all the essential methods of taxonomy, its aims and auxiliary sciences, and also has space for concise information regarding evolution, plant distribution, phytogeography, nomenclature, history of systems, and the characteristics and definitions of the taxonomical units, in addition to the apparently necessary mentioning of Marxist philosophy and doctrines combined with Lysenkoism, which nobody needs to read, in the Preface. Despite its conciseness, this book still remains interesting, readable, and very stimulating for the student and even the more advanced reader.

Plant Classification is a magnificent volume of 688 pages and innumerable pictures of high quality, superbly printed on very good paper. In the Preface some of the principles of the book are explained, and the volume is defined as an elementary text because it deals primarily with the higher units and ignores the lower categories. It must be said that this is a new definition of an elementary text in taxonomy, and the exclusion, though not complete, of cytogenetics and experimental studies as being "advanced" is certainly wrong and hardly aimed at inducing more life and greater interest into the subject. Although this is perhaps not explicitly stated, the main purpose of the book seems to be to announce "a new system of classification" which is said to be "combining the best features of the old systems with interpretations based upon new data." In other words, the book is not at all a textbook for students and least of all for elementary teaching of taxonomy, but rather a handbook for taxonomists interested in classifying higher categories. For this it is highly commendable. Some chapters have been added to make the book saleable to a somewhat larger public. In these chapters the author expresses the views upon which he bases his system, and it must be understood that all these views are not beyond disagreement, as is unavoidable in this critical subject.

Although the main part of the book is a manual of the orders and families of higher plants, and keys to their identification, very important chapters give the taxonomical vocabulary. More exact descriptions of all the characters of taxonomical interest are hardly available elsewhere, and the very informative pictures add much to the quality of these chapters and make them indispensable for those working in these fields. The short but clear chapter on preparation and preservation shows many good methods used by the author to facilitate the work and ascertain splendid results with inexpensive tools.

As cannot be avoided in a book of this kind, many expressions and several explanations are deemed disputable, and the selection of examples might perhaps also be questioned here and there. It is peculiar that the author prefers to explain evolution by the aid of animal material, although plants are also mentioned. The cytological background of the evolution of species is touched upon, but although alloploidy is demonstrated from *Galeopsis*, *Spartina*, and *Raphanobrassica* (without reference to Müntzing, Huskins, and Karpechenko!), the tremendous significance of polyploidy of all kinds in plant evolution is left aside or minimized. Also, when the development of new taxa is explained, gradual speciation seems to be the only kind the author accepts, despite the fact that perhaps 30% of all higher plants have developed their basic barriers by abrupt speciation which is fundamentally different from all the examples given. Because of this, the diagrammatic explanations of isolation processes do not fit more than two-thirds of the cases known. The role of hybridization is perhaps overemphasized at the cost of abrupt speciation, and the author seems to feel that introgressive hybridization is of greater importance than several other evolutionary processes. One must feel that, after the statement in the Preface that the "application of both cytogenetic and experimental investigations to plant taxonomy is . . . appropriate to only the advanced text" and thus, in the view of the author, not to his book, it is a little peculiar that he nevertheless prefers to discuss these matters even so superficially. This remark also applies to the very dim "discussions" of the definition of species in a footnote on p. 450. Probably the reason for the inclusion of this chapter is that even classical taxonomists in America have the feeling that a textbook without some chapter on cytogenetics is not acceptable; in fact, it would be better if all such discussions were left to those who really are well acquainted with the subject.

It would be of interest to discuss the advantages and disadvantages of the new system proposed. This must, however, be left to the specialists. It is evident, nevertheless, that the author proposes many new arrangements which are likely to sur-

vive the system as a whole, and some of his improvements are so natural that it is astonishing that they have not been proposed long ago. Only time can judge the applicability and value of a system, and it is to be hoped that it will not treat this one in the same forgetful way as most other proposals of the past.

A conclusion of this review without emphasizing the very high quality of the illustrations would not be fair. Many of these may be too large and expensive in reproduction, but they are all of such unusual class that there can be no doubt that they will be used and republished often in the future. This is true not only for Laudermilk's many pictures but in equally high degree for those marked L. B. and evidently drawn by the author himself.

This text by Lyman Benson is an achievement of unusual quality and quantity, and one which is likely to be a standard work of reference in taxonomy for many years to come. It can be heartily recommended to all those who are interested in the classification of the major categories of higher plants, and also as a handbook where definitions of all taxonomical terms are easily available. It is a highly advanced textbook to be used at the higher levels of taxonomy, and it is very likely that it will appeal also for these classes at European institutions, where it could be a worthy representation of the best in American taxonomical science.

ÁSKELL LÖVE

DAS LEBEN DER GEWÄCHSE. *Ein Lehrbuch der Botanik. Erster Band. Die Pflanze als Individuum.*

By Friedrich Oehlkers. Springer Verlag, Berlin, Göttingen, and Heidelberg. DM 39.60. viii + 463 pp.; ill. 1956.

Most textbooks of botany study the plant as a part of the system, or as a link in an evolutionary chain involving the populations of the past and present. This volume claims to base its approach on the plant as an individual, so that the student starts by learning about the cells and their constituents, morphology and development, and continues to get information about the cells as a whole, their form, size, and origin. There follows a short chapter on histology in which the problems of the cell groups and tissues are discussed and also the differentiation of cells and the main types of plant tissues; next is a long and detailed chapter on organography, from the embryonic structures to stems and roots. The main portion of the book gives very detailed descriptions of reproduction and inheritance and leads up to "the end": age, sickness, and death. The last part of the volume is a concise report on developmental physiology, in which phenomena from germination, through growth, differentiation, regeneration, form changes, to reproduction are described in physiological terms, ending with explanations of sex determination, fertilization, and meiotic divisions.

It is difficult to evaluate this text from the point of view of American textbooks, since it is written for students with a different approach, and is at once both introductory and advanced. Its prevalent cytogenetical and evolutionary approach makes it commendable as a complementary textbook to American courses based on classical views; at the same time its use for students of cytogenetics would add much to their understanding of classical botanical phenomena and also of the proper use of the terminology of general botany. Its very modern information and clear, explanatory pictures make it an ideal manual for professors teaching general botany, since most of the recent European results mentioned and depicted are not yet included in textbooks on this side of the Atlantic.

Oehlkers has performed an interesting experiment by writing his textbook on the basis of the cell and its development, and the result is good. His great cytogenetical knowledge clearly permeates all chapters, without distorting any of the facts of other disciplines. If he succeeds also in completing the proposed second volume—presumably to be on geobotany and taxonomy—as nicely, the finished work will be an unusually good review of contemparary botany as seen from cytogenetical and evolutionary points of view. The first volume is a highly commendable textbook for all botany and cytogenetics students who possess a basic knowledge of the German language.

ÁSKELL LÖVE

POLLEN AND SPORE MORPHOLOGY, PLANT TAXONOMY. *Gymnospermae, Pteridophyta, Bryophyta. (An Introduction to Palynology, II).*

By G. Erdtman. Almqvist & Wiksell, Stockholm; [The Ronald Press, New York]. $8.00. viii + 151 pp. + 5 pl.; text ill. 1958.

The author of this book has previously published a number of much appreciated handbooks in palynology. The present volume is the second in a series of which the first, published in 1952, included drawings of pollen grains of angiosperms and an informative text. The present volume, however, includes only the pictures of the pollen of gymnosperms and of the spores of pteridophytes and mosses; the text is to be published as a third volume later on. This not only means a higher cost for those using the book, but it is also a great dis-

service to the author himself, since the volume without a text is very faulty and of considerably less interest than it would be otherwise.

In the first volume there were representative samples from many families of higher plants, thus making the treatment of interest also to non-palynologists, and especially to taxonomists concerned with the classification of the higher units. The gymnosperms in the second volume are well represented, and so are the true ferns, whereas the fern-allies are virtually absent, except for a single species of *Equisetum* and unrepresentative samples of a few *Lycopodium* taxa. The situation grows still worse when it comes to the mosses, even though 23 families of hepatics and 40 families of true mosses are depicted. In many cases the lack of material of species from faraway lands could be used as an excuse, but the value of the book would have increased greatly if only all the Scandinavian genera or species easily available to the author had been included, rather than stray samples from genera of other regions.

As in the first volume, supplements by two other authors are included in the book, both of them about technique for palynologists. Although these papers certainly are useful, their proper place is in some palynological journal. Their exclusion would, however, have made the book one-sixth shorter.

No doubt, despite its incompleteness, the new book by Erdtman will be of interest to all palynologists and of great assistance to all those interested in identifying spores of the groups included. Readers would surely have been more than willing to wait somewhat longer, however, if they could have had the second volume complete with the necessary text at a price more comparable to that of the first, valuable volume.

ÁSKELL LÖVE

DIE BIOLOGIE DER BLÜTE.

By Fritz Knoll. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM 7.80. vi + 164 pp.; ill. 1956.

This short review of the biology of the flower is one of the many books in the series on "understandable science" published by Springer-Verlag in recent years. Fritz Knoll in Vienna, a well-known authority on flower biology, has written in such a way that this book can be useful for students and laymen interested in the different problems connected with flowers and flowering. Although the first 20 pages review the different kinds and parts of flowers and their basic phenomena, the bulk of the text describes different mechanisms of pollination, mainly those connected with insects and other animals. The nature of the book may have required that the text be restricted to classical explanations only, and references to modern and more critical studies performed outside the German-speaking world seem to be absent. Hence, there is no mention of the remarkable findings observed by Grant in California *Aquilegia;* and the critical studies by Hagerup on rain pollination are ignored entirely.

Several informative pictures are mixed with the text, which is nicely produced on good paper. Students with a sufficient knowledge of German, and with an interest in flower biology, will enjoy the book and can get from it much information about the classical Central European views on pollination mechanisms and the still too little understood relation between flowers and insects, or other true or hypothetical pollen vectors.

ÁSKELL LÖVE

HOW TO KNOW THE MOSSES AND LIVERWORTS.

By Henry S. Conard. William C. Brown Company, Dubuque. $3.00 (cloth); $2.50 (paper). ix + 226 pp.; ill. 1956.

Twelve years have elapsed between the original publication of *How to Know the Mosses* (*Q. R. B.*, 21: 186. 1946), and the current revision. The eminence of the author as an authority on these groups is a sufficient guarantee of the handbook's scientific merit. Its popular presentation has not been destroyed in the process of revision and expansion, however. Nearly all the added space has been devoted to an increase in the pictured keys, which now comprise 165 pages, an increase of 55. In the light of the rapid increase in costs of books during the past decade, it is gratifying that the basic cost per page of this excellent handbook remains almost the same as twelve years ago. In fact, a purchaser who is willing to pay 50 cents more for the hard-cover edition will actually obtain it at a lower cost per page than in 1944!

BOOK 5 OF FLORA HAWAIIENSIS *or New Illustrated Flora of the Hawaiian Islands.*

By Otto Degener. The National Science Foundation, Washington, D. C. $5.00 (looseleaf). Ill. 1946–1957.

This is a new volume of loose-leaf sheets, not yet a flora in the usual sense of the word, but rather a collection of descriptions of, articles about, and pictures of selected plants from the Hawaiian Islands. When and if completed, it may make up a scientific flora of considerable interest and un-

usual character. It is not a manual for the layman, yet its drawings are so clear that anybody can recognize the plants. It is far from being complete now, and it is doubtful that it ever will be, since the Hawaiian flora is still very insufficiently known, and is now being destroyed at such a fast pace by engineers and farmer-businessmen that nobody can guess how many remarkable and irreplaceable species are made extinct every month. One may sometimes wonder why a nation which shows such a great interest and spends so much money and time to prevent the extinction of a single species of crane on the mainland does not spend comparable time and money for all the many species of plants in the most beautiful and least understood of American floras, that of the Hawaiian Islands. It certainly is worthy of considerably increased interest and of very much bigger and more effective institutions for its study and preservation than are now met with on these friendly islands of tourism. The support given to Degener and some other botanists by the National Science Foundation is a step in the right direction, but it is almost like a droplet in the ocean and will hardly save many of the species from disappearing still unknown.

Although the species included in the flora by Degener usually get only one page of text with a picture on the next one, differences in the type used make it possible for the author to give some species many times more words than others receive. The genera are described shortly, their names explained, and the type species mentioned. In addition to a concise description of each species, synonyms are given, and also type localities, local range, and distribution outside the islands, if the plant is not endemic there.

This may seem to indicate that the flora is written in the same dull language as other such books, with exactness dominating every description, and all information restricted to a minimum. Although this is so in many cases, it would not be fair to overlook the innumerable small remarks on the history of many of the plants and of their uses, since these statements contribute so much charm in places. In connection with the Caricaceae, for instance, Degener tells the reader about the tenderizing of meat by the aid of papaya juice, and also how the fruit and leaves can be prepared as food. We are even told that the papaya furnishes a heart-stimulant, a beer-clarifier, and a process for reducing the shrinkage of wool. A few pages later, in connection with *Syzygium*, the author suggests "that any one eating the small acid fruits should disseminate the soft seeds in favorable conditions in the neighborhood to stave off extinction of this interesting *ohia ha*." The small remarks on the nomenclature and history of the introduced plants are also often fascinating in their conciseness.

The book can be recommended to all botanists interested in the remarkable flora of the islands of the Pacific Ocean and also to those who plan to visit the Hawaiian Islands for pleasure or study. It is to be hoped that Degener will soon be able to add to the book many more species which are now lacking, although the writing of such a manual for a region like the Hawaiian Islands is a task which really needs hundreds of well-equipped botanists. What has already been achieved in Hawaii by several botanists, both in the past and at present, is highly commendable, but it is only the very beginning of the botanical exploration of the many mystical islands of the Pacific Ocean.

ÁSKELL LÖVE

FLORA OF THE BRITISH ISLES. *Volume I.* *By A. R. Clapham, T. G. Tutin, and E. F. Warburg; drawings by Sybil J. Roles. Cambridge University Press, New York and London.* $5.00. vi + 144 pp.; ill. 1958.

When the *Flora of the British Isles*, by Clapham, Tutin, and Warburg, was published in 1952, a long-felt need for a modern British flora was adequately filled. This flora was not only thoroughly modern, it was and still is the most progressive treatment available of the plants of many region in western Europe.

Although the trend toward illustrated floras had become well established in Europe by 1952, and especially in the first-class manuals of the Norwegian flora by the Lids, the new British flora had only a few, inadequate illustrations of the kind in use in Central Europe in the first part of the century. This did not matter much, since the descriptions were very clear and the species concept and nomenclature up to date; but the authors apparently felt that they should follow the current trend and publish drawings of British plants in a separate volume. The result is the publication under review, and it is only the first of four such octavo books to be published in the future. It is apparent from the arrangement of four pictures on each page that the original plan had been to publish the illustrations in volumes the same size as the *Flora*, so that these could easily be carried into the field. As the volume is now, it is made only for large shelves and will hardly be of much use for those who need on-the-spot application.

Many of the illustrations are superb, and the habitat sketches of the water plants are very informative. It is my impression, however, that the reproduction has lowered the standard of the origi-

nals so much that several of the drawings are not of the quality one would expect in a companion volume to the very modern text. Compared to the recently published drawings by Mrs. Lid in the Norwegian flora, by Hagerup and Petersson in the Danish *Atlas*, and by Miss Ross-Craig from Britain, the present volume suffers badly. It is to be hoped that the following parts will be improved; otherwise it would be of doubtful value to compete with Miss Ross-Craig's drawings for the very same flora, despite the great drawback that her pictures are published at much too slow a pace. Use of a larger scale and of more details in this companion volume to the *Flora of the British Isles* would immediately increase the quality and usefulness of all the pictures.

The additions of species not mentioned in the parent flora and some of the alterations in nomenclature indicate that a new edition of the text will have to be published soon. It is to be hoped that this will not be delayed by the printing of the companion volumes, since the pictures are not as irreplaceable as the still more modern treatment to be expected in future editions of the text.

ÁSKELL LÖVE

HANDBOOK OF THE RUBI OF GREAT BRITAIN AND IRELAND.

By the late W. C. R. Watson; drawings by Ruth M. Ball and A. W. Darnell. Cambridge University Press, New York. $12.00. xii + 274 pp.; ill. 1958.

As in eastern North America, the genus *Rubus* in Europe is among the most critical groups of higher plants known properly only by a few specialists, who often are amateurs spending all their spare time on these plants. The classification of the *Rubi* is known to be critical and often disputable, since taxa given the rank of species are not infrequently only apomictic hybrids or nothomorphs of ephemeral duration, and many taxonomists avoid the genus simply because they feel that its species are worthless for studies on distribution and evolution. In fact, however, the possibilities of an exact classification of these perhaps recently evolving taxa may often be of considerable historical interest, and studies on their distribution and reactions may be expected to result in many conclusions of great significance. It is, therefore, a pity that most specialists spend all their time in identifying these plants, whereas others find the taxonomical difficulties too great for studies for which the group is especially fitted. The reason for the latter is often that ordinary manuals, in order to save space and costs, do not include exact keys and descriptions for all the *Rubus* taxa.

The present volume gives a very thorough review of the many species and races of *Rubus* recognized by the late W. C. R. Watson, who knew the genus better than did any other British botanist. Good keys make it possible to identify the series and their species, and every species is described concisely when its synonymy and distribution are given. Whenever known, the degree of polyploidy of the taxa is shown, and 50 out of the 391 species are excellently illustrated.

The book will certainly be of great interest to British and European botanists, and in eastern North America it may be of some assistance to those interested in the genus *Rubus*, although the variations in this country are different. The introductory material is of great benefit. Although this is a monumental work on a remarkable genus, it is to be hoped that in the future the group will be treated taxonomically somewhat more sensibly, so that species names will eventually be replaced by subspecific, varietal, and nothomorphic designations wherever these are more appropriate. It is evident that the last designations—the nothomorphs—will later replace a large number of taxa now named as species in *Rubus*, at the same time greatly enhancing the interest of other botanists in this variable group. When this revision is undertaken, the Watson monograph will be of immense importance, as being the most authoritative report ever written on the British blackberries.

The book has been prepared from the manuscript of Watson after his death, by Sell and Woodhead. Like the printer and publisher of this attractive volume, they have done a good job.

ÁSKELL LÖVE

ORCHIDS OF PERU. *Fieldiana: Bot. Vol. 30, No. 1. By Charles Schweinfurth. Chicago Natural History Museum, Chicago.* $4.50 (paper). viii + 260 pp.; ill. 1958.

The present publication is the first of an anticipated 4-part work to include all species of orchids known to occur in Peru. This monumental and authoritative publication represents 35 years of scholarly research by one of the world's outstanding students of the Orchidaceae. It is the first attempt to describe in detail all of the known species of any Andean region and represents an especially important contribution to our knowledge of the flora of South America.

The Orchidaceae, one of the largest, if not the very largest, of the flowering-plant families, is especially well represented in Peru, which, with the

exception of neighboring Colombia, has the largest number of species known from any Andean country, with a total of 119 genera with 1122 species and varieties. The present part treats 26 genera (*Altensteinia, Baskervilla, Buchtienia, Chloraea, Cranichis, Cryptophoranthus, Elleanthus, Epistephium, Erythrodes, Gomphichis, Habenaria, Lepanthes, Masdevallia, Phragmipedium, Physosiphon, Pogonia, Ponthieva, Prescottia, Pseudocentrum, Pterichis, Sobralia, Spiranthes, Stelis, Stenoptera, Vanilla, Wullschlaegelia*), and includes 629 species and varieties, 45 of which are illustrated with excellent line drawings clearly showing diagnostic characters. Keys are provided to the genera as well as to the species in each genus. The keys are not entirely natural but are constructed primarily to facilitate the identification of the species.

The synonymy of each species is provided, together with a full description of the plant, the citation of collections studied, the Peruvian and extra-Peruvian distribution, and information relative to economically important species. The genera are arranged according to the scheme of Schlechter with some modifications. This publication will become the model and basis for future publications dealing with the orchids of adjacent areas.

T. G. YUNCKER

THE SLOANE HERBARIUM. *An Annotated List of the Horti Sicci composing it; with Biographical Accounts of the Principal Contributors.*

Revised and edited by J. E. Dandy; based on records compiled by the late James Britten; introduction by Spencer Savage. British Museum (Natural History), London. £7 7s. 246 pp. + 2 pl. 1958.

Sir Hans Sloane (1660–1753) is considered by some historians to be, more than any other, the founder of the British Museum (Natural History). It is certain that, as a President of the Royal Society and a comparatively wealthy individual, he had great influence on the botanists of his time. The Sloane Herbarium is a remarkable survival from the past, a mine of information for the historian of botany and horticulture in the 17th and 18th centuries. And yet, as Dandy points out in his Preface, the great importance of the contents of this Herbarium has not been generally appreciated, largely due to the lack of a publication giving a full account of its contained collections.

The book, so skilfully organized by Dandy (Keeper of Botany, British Museum), is not a catalogue of the specimens in the Sloane Herbarium, but a guide to its contents, with historical information about the contributors. Although two short chapters (an Introduction by Spencer Savage, and a chapter on Sloane and his Herbarium by the late James Britten) have been contributed, the bulk of the work is due to the energy and high scholarship of Dandy, to whom botanists and students of the history of biology owe a debt of gratitude.

The Sloane Herbarium, like others of its period, consists of bound volumes containing dried plant specimens; there are 265 such volumes in this Herbarium, and the number of included specimens has been estimated at 120,000. The chief value of the Herbarium to botanists lies in the type specimens it contains, especially of Linnaean species. Linnaeus did not describe any actual specimens in the Sloane Herbarium, but he based many species on published figures and descriptions of plants preserved in it. Actual types in such cases, therefore, are the specimens preserved in the Sloane Herbarium, as collected by such individuals as Plukenet, Petiver, Kaempfer (in Japan), Catesby (in Carolina and the Bahamas), and Sloane himself (in Jamaica). Students of the floristics of West Indian and eastern American regions, and of many other parts of the world, are aware of the basic importance of these type specimens for a stable nomenclature.

Sloane had begun to form his Herbarium before he was twenty-one years of age, and his visit to Jamaica (1687–1689) gave impetus to the collections, which received contributions from at least 300 individuals. An intimate of Ray, and a friend of Tournefort and Linnaeus, Sloane was in touch with practically all the botanists of his time. Dandy's concise and scholarly account of the contributors to his Herbarium includes notes on most plant collectors of the period, both the distinguished and the obscure. This alphabetically arranged section, occupying half of the book, is perhaps its most valuable part.

The Sloane Herbarium, when compared with the meticulous and more famous Linnaean Herbarium, was not kept in an orderly manner. Linnaeus himself, when examining it, considered it "in complete disorder." Nevertheless it contains priceless specimens, and Dandy's book fills a real need in making these known in a systematic fashion. A concluding section of facsimiles of handwritings of 96 contributors to the Sloane Herbarium will be most valuable to students of the history of botany.

Although priced at more than $20.00, *The Sloane Herbarium* is a necessity for every library consulted by research workers in plant taxonomy; it will also be desired by scholars concerned with the development of biology in the 17th and 18th centuries. Its pleasing format and excellent typog-

raphy lead one to congratulate the printers as well as the editor and principal author.

A. C. SMITH

TROPICAL AMERICAN MYRTACEAE. *Notes on Generic Concepts and Descriptions of Previously Unrecognized Species. Fieldiana: Bot., Vol. 29, No. 3.*

By Rogers McVaugh. Chicago Natural History Museum, Chicago. $1.50 (paper). ii + pp. 145–228; ill. 1956.

PLANT MORPHOLOGY AND DEVELOPMENT

MORPHOLOGY OF PLANTS.

By Harold C. Bold. Harper & Brothers, New York. $8.00. xxiii + 669 pp.; ill. 1957.

This is a large volume which is both an introductory textbook and an advanced treatment of the fundamental subject of plant morphology in the widest sense of the word. The book is written in the common descriptive style, superbly illustrated with photographs and good drawings, and it reviews the morphology of the entire plant kingdom, from the lowest to the highest evolved groups, while at the same time it summarizes the systematic treatment of the major categories. No doubt a student can obtain a thorough knowledge of the subject from this textbook, although very few universities allow enough time for such a detailed study of morphology alone. When reading the book, one wonders why the author does not use different type to distinguish important from less necessary data, so that the book could also be used in places where limited time is available. Such a differentiation in style has long been made in the best and most widely used botanical textbooks in Europe, notably in the German book usually attributed to Strasburger and published quite frequently in thoroughly revised editions.

Critical remarks may no doubt be made about many statements in the book, since it is impossible to write so extensive a manual without touching upon a number of controversial matters. Those who have worked on sex chromosomes may find it strange that these are mentioned only in connection with the mosses, without an acceptable explanation of the mechanism of sex determination of the individual; and it may also seem somewhat peculiar not to mention other chromosomes at all, although chromatin is named in connection with the blue-green algae. There are, however, many good excuses for having done this. It saves the student time and money not to have to read about these details here, since other textbooks usually repeat the same descriptions, as if no other book had ever mentioned them.

The author makes his own variation of the classification of the major categories, an indulgence that seems to have become customary even in textbooks on subjects other than taxonomy. This may serve its purpose, but one must wonder what meaning there is in comparing this system to Tippo's summary and incomplete classification rather than to the well-known systems by Engler or Hutchinson or others who have written widely accepted books on the subject. There is no doubt that the system proposed is reasonable, although one may sometimes wonder why certain changes are made; it is, for instance, a little peculiar to a cytotaxonomist to see that a morphologist includes not only the Gnetaceae and Welwitschiaceae in the Gnetophyta, but also the Ephedraceae. The first two may well be related, whereas morphological as well as cytological evidence clearly indicates that *Ephedra* is no less distinct from *Gnetum* than it is from the real conifers.

The Morphology of Plants is, as a whole, a very well balanced book which can be highly recommended to those universities which give botany a fair place in the curriculum and which train students in all the essential parts of the subject. The book is not easy reading, but anyone working thoroughly and critically through all its chapters will have obtained a substantial basis for further studies in many fields of botanical science.

ÁSKELL LÖVE

EMBRYOLOGISCHE UND HISTOGENETISCHE UNTERSUCHUNGEN AN MONOKOTYLEDONEN. *Botanische Studien, Heft. 7.*

By Hermann von Guttenberg. VEB Gustav Fischer Verlag, Jena. DM 16.40. (paper). viii + 161 pp. + 10 pl.; text ill. 1957.

This is a collection of scientific papers concerning embryological and histogenetical studies on monocotyledons made by von Guttenberg and some of his collaborators in Rostock, Germany. In addition to a preface and a postscript by von Guttenberg, it includes the following 5 papers: (1) Pankow and von Guttenberg, Comparative studies on the development of monocotyledonous embryos and seedlings. These investigations were made on plants of *Sorghum vulgare*, *Tradescantia virginica*, and *Canna indica*. (2) Heydel and von Guttenberg, Comparative studies on the development of primary, secondary, and branch-bearing roots in some liliaceous plants: *Allium giganteum*, *Asphodelus albus*, *Hemerocallis ochroleuca*, and *Anthericum ramosum*. (3) von Guttenberg and Jakuszeit, On the development of the embryo and the primary root of

Galtonia candicans, and on the differentiation of the growing point of the root of *Allium*. (4) von Guttenberg and Semlow, On the development of the embryos and seedlings of Cyperaceae; (5) von Guttenberg and Riebe, on the same in Bromeliaceae. The book is of special interest to those working upon the comparative anatomy and histology of the higher plants.

ÁSKELL LÖVE

PROTOPLASMATISCHE PFLANZENANATOMIE. *Protoplasmatologia. Handbuch der Protoplasmaforschung, Band XI.*

By Lotte Reuter. Springer-Verlag, Wein. DM 34; $8.10 (paper). iv + 131 pp.; ill. 1955.

It is seriously questionable whether many biologists will want to purchase this monograph at a cost of 6.2 cents per page, no matter how fine it may be. The policy of the publishers appears to be to sell this series to a small number of libraries and by an exorbitant price to recover enough to make a profit even from a minimum of sales. Such policy must clearly be condemned, however, as inimical to the diffusion of scientific knowledge.

The monograph contains two major sections, the first dealing with methods of protoplasmic plant anatomy, examined from the standpoints of cellular physiology and cytomorphology; and the second, dealing with the results of such studies, divided into the protoplasmic anatomy of the cell, of tissues, and of organs. A brief final section, Rückschau und Ausblick, takes a look at normal and abnormal development and regeneration. The emphasis throughout the work is on cell physiology and not on morphology. The newer evidence related to the fine structure of cellular components as revealed through electron microscope studies is apparently not considered to be relevant to the subject and is not included within the purview of the monograph.

BENTLEY GLASS

PLANT PHYSIOLOGY

DIE SAFTSTRÖME DER PFLANZEN. *Verständliche Wissenschaft, Band 58.*

By Bruno Huber. Springer-Verlag, Berlin. DM 7.80. viii + 126 pp.; ill. 1956.

Many thick volumes have been written about the sap currents in plants, and several concise reviews are available for students interested in the mysterious forces, stronger than the best man-made pumps, which move the water up to the tops of the highest trees. There are, however, very few reviews as clear and as free from professional terms as this book by Professor Huber of München, and even non-physiologists will benefit much by reading it to renew or widen their knowledge of the basic phenomena it describes.

The book is evenly divided into two long parts: one on the upward and another on the downward currents in the stem. Both are based on anatomical as well as physical experiments and explanations, and classical and modern approaches are mentioned equally in the well-balanced presentation. The effects of various environmental factors are demonstrated, but although the aim of the text is to give information in regard to what is known in this field of physiology and anatomy, the need for further studies of many phenomena is stressed, so that the interested student will find here many challenging questions he may want to explain himself.

Huber says in his introduction that since the book was written in a small place in the South Tyrol, far fram library facilities, fundamentals had to be separated from details in the explanations. It could be added that the book has not suffered from the concentration of facts, and the result is so well-balanced and understandable that one feels it is a pity that lack of knowledge of the German language may prevent many of those who need this kind of explanation from enjoying the book.

ÁSKELL LÖVE

ECONOMIC BOTANY

A TEXTBOOK OF PLANT VIRUS DISEASES. *Second Edition.*

By Kenneth M. Smith. Little, Brown & Company, Boston. $12.00. vii + 652 pp.; ill. 1957.

This edition, published two decades after the first, will be an invaluable addition to the personal library of every person interested in plant viruses and the diseases they cause. The second edition is like the first with respect to the type of information given about each listed virus, but the text has been completely rewritten, the information on each virus brought up to date, and the list of treated viruses extended to include practically all of those recognized today.

The viruses are listed alphabetically by their English common names. In so far as it is available, information is given on the general properties of each virus, its transmission, its differential host range, its geographic distribution, and the diseases caused by it. Synonyms are given for many viruses, and numerous cross references are inserted throughout the text. The information given is commendably complete and accurate in view of the encyclopedic nature of the treatment. The very few omissions from the list of viruses dealt with are,

for the most part, viruses of minor importance or of limited geographical distribution. The few errors of fact noted concern viruses not yet thoroughly characterized or those inducing diseases of complex etiology. Unfortunately, distinction is seldom made between naturally occurring diseases and diseases observed only following experimental inoculation.

The only index is an index of synonyms, since the viruses are listed alphabetically and the references are collected in an alphabetically arranged bibliography. Doubtlessly, many users of the book will regret the absence of an index of hosts and vectors. The deficiencies mentioned are minor in comparison with the many valuable features of the book. Its publication fills a long-felt need, especially in English-speaking countries.

A. F. Ross

Investigation of Virus Diseases of Brassica Crops. *Agric. Res. Coun. Rept. Ser., No. 14.*

By L. Broadbent. Cambridge University Press, New York. $3.00. vii + 94 pp. + 8 pl.; text ill. 1957.

This book is a compilation of results from an extensive series of field experiments conducted with the cooperation of numerous persons in various parts of England. The brassicas are important food crops (especially cauliflower, Brussels sprouts, and cabbage) and agricultural crops (especially turnip and rutabaga) in this country. Increases in acreage and intensity of culture beginning early in World War II have been followed by enhanced importance of destructive virus diseases. The treatise is concerned with the two most important viruses, viz., turnip mosaic virus (CBRSV) and cauliflower mosaic virus (CIMV). While the book is dull reading for anyone but a plant pathologist or entomologist interested in this particular area, it contains a reservoir of information which should be of interest to the general biologist. Although the two viruses are transmitted most commonly by the same two aphids, *Myzus persicae* (Sulzer), and *Brevicoryne brassicae* (L.), their occurrence in the field may be quite different. Although CIMV infects only members of the cruciferous family, while CBRSV has a host range extending into many families of dicotyledons, the former is by far the most important economically in England. One reason for this is that CIMV multiplies most rapidly in cool summer weather, while CBRSV requires higher temperatures than England usually affords for optimum development. Quite the opposite holds in many parts of the United States. Both viruses depend upon aphids for transmission from infected reservoir plants to new plantings. As infected plants grow the CIMV concentration increases in the upper younger leaves and remains high in old plant parts, while with CBRSV the opposite trend prevails. Aphids alight and multiply on young parts, and winged forms move on as plant parts age. Thus CIMV is most readily available and consequently most widely distributed. Another point of general interest to biologists is that aphids retain CIMV longer than CBRSV; this again favors the former. The destructiveness of the diseases is correlated with the age at which plants are infected. The earlier this happens, the greater the disease span and the the greater the damage. It is of interest that thorough and frequent spraying of seed beds with contact and systemic insecticides had little or no protective value, because one feeding by one viruliferous insect which escaped the chemical was all that was needed to permit infection. On the other hand, nonsusceptible barriers of barley spaced frequently in seed beds distracted aphids sufficiently to cause appreciable reduction of disease. The author points out, however, that ultimately the most successful control lies in development of suitable resistant crop varieties.

J. C. Walker

Diseases of Fruit Crops.

By Harry Warren Anderson. McGraw-Hill Book Company, New York, Toronto, and London. $8.50. viii + 501 pp.; ill. 1956.

This book represents the first attempt since 1920 to collect and summarize the information on the diseases of deciduous fruits in the United States and Canada. The intervening years have witnessed a tremendous increase in the literature on that subject. Anderson has accomplished a creditable task of assembling, condensing, and reporting the more important literature. The result is a 13-chapter book, useful in the classroom and as a source of information for practical horticulturists. Four chapters are devoted to diseases of pome fruits, two to diseases of drupe or stone fruits, and one chapter each to diseases of brambles, grape, strawberry, gooseberry and currant, cranberry, and blueberry. Diseases of the olive, the fig, the Persian walnut, the filbert, and the pecan are not included. Though these crops are grown only in the western or southern United States (or both), they are important elements in the horticultural industry of the nation, and the diseases affecting them are of concern to a large number of people. For the other crops named, however, all major and many minor diseases incited by fungi, bacteria, viruses, and nematodes are included. In addition, nonparasitic diseases possessing well-defined symptoms are dis-

cussed. The language of the book is clear and concise, and the subject matter well-organized.

E. E. WILSON

GENERAL AND SYSTEMATIC ZOOLOGY

LABORATORY SYLLABUS FOR GENERAL ZOOLOGY.

By D. Elden Beck. Burgess Publishing Company, Minneapolis. $4.00 (paper). ix + 293 pp.; ill. 1956.

This laboratory manual differs from the conventional zoology manual in two significant respects. It strongly emphasizes Growth, Development, and Function (6 of a total of 14 exercises); and it eschews the usual survey of animal types, phylum by phylum. Instead of the latter, it places representative Protozoa under the Cell Concept, representative Cnidaria under the Metazoan Concept, and reduces the study of other types to three: the grasshopper, the frog, and the mammal. General biological principles are emphasized more than detailed studies of anatomy and morphology. Genetics, Ecology, Zoogeography, Taxonomy, and Marine Zoology each are allotted an exercise. Work sheets are provided, and there are many excellent labeled figures, both diagrams and photographs. For a one-semester course.

AN INDEX TO THE GENERA AND SPECIES OF THE FORAMINIFERA. *Smithsonian Misc. Coll. Vol. 132 (whole volume). (Pub. 4226).*

By Charles Davies Sherborn. Smithsonian Institution, Washington. $3.50. viii + 485 pp. 1955.

This comprehensive work was first published in 1893 and 1896 in two parts, and has long been out of print. The recent index of foraminiferans by Hans E. Thalmann has covered the period 1890–1950, but did not duplicate the earlier work by Sherborn. To provide a complete index to the group the former work has now been reprinted by photo-offset, both parts being combined in this single volume. All workers with Foraminifera will clearly find it indispensible.

STUDI E RICERCHE SUI TENTACULIFERI QUADRO DELLA BIOLOGIA GENERALE. *Biologia Animale. Sezione III, Vol. 1, No. 4.*

By Mario F. Canella. Annali dell' Università di Ferrara, Ferrara. Lit. 3000 (paper). Pp. 259–716 + 17 pl.; text ill. 1957.

Canella's work, unfortunately published in a journal not commonly seen by many biologists who might well be interested in it, may be considered invaluable even if viewed only as an up-to-date source book of information concerning the systematics, morphology, and physiology of the suctorian ciliates. In this respect one need only mention the 457 pages, the 24 text-figures and 97 photomicrographs, and the 789 titles comprising literature actually cited. But Canella also has included original observations, and promulgation of several hypotheses as well as discovery of new facts concerning the morphology and life histories of a number of species. His discussions are always comparative in nature, and the views of other workers are treated critically and quite comprehensively. Topics covered include phylogenesis, systematics, developmental ("embryological") processes, the nuclear apparatus, sexuality, ultrastructure, the "silverline" system, behavior, and ecology.

The monograph is conveniently divided into six principal sections, with addenda appended to each. It is particularly in the addenda, occupying some 81 pages of finer print, that the author ventures beyond the Suctoria proper and considers some basic problems of general biological interest, such as the origin of the Metazoa, "chromosomes" in the ciliate macronucleus, nucleocytoplasmic interactions, the genetic continuity of cytoplasmic inclusions and the concept of "plasmagenes," the biosynthesis of proteins, and the contractility of protoplasm.

The treatise is written in Italian, with very brief synopses in English and German but an 18-page résumé in French.

JOHN O. CORLISS

POLYCHAETOUS ANNELIDS ERECTED BY TREADWELL, 1891 TO 1948, TOGETHER WITH A BRIEF CHRONOLOGY. *Bull. Amer. Mus. nat. Hist., Vol. 109, Art. 2.*

By Olga Hartman. American Museum Natural History, New York. $1.00 (paper). Pp. 239–310 + 1 pl. 1956.

This attractively printed publication is a tribute to the wide knowledge and painstaking work of Miss Hartman. It is also an impressive memorial to Aaron L. Treadwell, long-time Professor of Zoology at Vassar College, and it includes a brief account of his scientific life and a handsome photograph of the man.

The body of the work consists of a description and critical evaluation of each of some 125 new species of polychaetes which were collected and named by Treadwell. In addition, there is an alphabetical list of the 324 names of polychaetes erected by him, although they are here reduced

to 266 "valid" species. For each, Hartman gives the original name, with its bibliographic citation, the family name, the type locality, the location of the holotype or other authoritative specimen, revised name, if any, references, and comments. There is also an alphabetical list of the valid species with synonyms, a list of species by families, and a 9-page bibliography, a large portion of which is presumably a definitive list of Treadwell's publications from 1891 through 1948.

The Allan Hancock Foundation is to be congraulated for sponsoring this issue.

GAIRDNER B. MOMENT

THE *Frankliniella occidentalis* (PERGANDE) COMPLEX IN CALIFORNIA. (*Thysanoptera: Thripidae*). *Univ. Calif. Publ. Entomol., Vol. 10, No. 6.*

By Douglas E. Bryan and Ray F. Smith. University of California Press, Berkeley and Los Angeles. 75 cents (paper). iv + pp. 359–410; ill. 1956.

SYSTEMATICS OF THE SUBORDER TUBULIFERA (THYSANOPTERA) IN CALIFORNIA. *Univ. Calif. Publ. Ent. Vol. 13.*

By H. Edwin Cott. University of California Press, Berkeley and Los Angeles. $3.50 (paper). 210 pp. + 4 pl. 1956.

According to the author, this is the first monograph since 1924 to treat the thrips of California; and the earlier work is by now largely unusable for identifying species because of the taxonomic changes which have occurred in the meantime. Whether the new keys to the families Phlaeothripidae and Urothripidae are satisfactory and workable only a specialist can determine. Others will note that the number of species known to occur in California has almost doubled in the past 20 years, that the monograph introduces 9 genera now found for the first time to occur there, and that 12 new species are described herein. All families, genera, and species are redescribed in addition to the presentation of the new keys; and observations on the variation and distribution of each species, together with its biology, are offered.

AN ILLUSTRATED CATALOGUE OF THE ROTHSCHILD COLLECTION OF FLEAS (SIPHONAPTERA) IN THE BRITISH MUSEUM (NATURAL HISTORY). *Volume II. Coptopsyllidae, Vermipsyllidae, Stephanocircidae, Ischnopsyllidae, Hypsophthalmidae, and Xiphiopsyllidae.*

By G. H. E. Hopkins and Miriam Rothschild. British Museum (Natural History), London. £6 6s. xii + 445 pp. + 1 map + 29 pl.; text ill. 1956.

The plan of this volume follows precisely that of the first, which was published in 1953. (*Q.R.B.*, 29: 380. 1954). Approximately 1200 species of the known 1,500 species are now represented in the Rothschild collection. Keys and short descriptions for rapid identification of specimens are provided; no comprehensive descriptions have been attempted. It is sufficient to repeat the words of the earlier reviewer of this work: "This is the most important and the only comprehensive work which has been published on the fleas of the world." It will long remain an essential reference work for entomologists. Its excellent format and illustrations and the care with which it has been prepared should make all who use it feel deeply indebted and grateful to the anonymous donor whose generosity has made the publication of Volume II possible.

SEALS, SEA-LIONS, AND WALRUSES. *A Review of the Pinnipedia.*

By Victor B. Scheffer. Stanford University Press, Stanford. $5.00. x + 179 pp. + 32 pl.; text ill. 1958.

Not since Allen's monograph of 1880 have the pinnipeds been completely reviewed, although many contributions to the knowledge of this group of mammals have been made since then. Scheffer's extensive bibliography attests to this and in itself will make this book an important reference for anyone studying seals.

The book may be considered to be composed of two parts, one dealing with the characteristics, evolution, and phylogeny of seals, the other with their classification. Under the former, which includes only 44 of the 148 pages of text, will be found most of the material of general interest. The first chapter deals with the general characteristics and adaptations of the pinnipeds, and may briefly be described as "pinniped biology."

In dealing with the systematics and phylogeny of seals, the author follows the general plan of Simpson's classification, but departs from it in allowing the group full ordinal rank. Within the 3 families he recognizes 20 genera, most of which are monotypic. *Phoca, Pusa, Histriophoca,* and *Pagophilus* are all accorded full generic rank. The southern sea lions he recognizes as belonging to 2 genera, *Otaria* and *Neophoca*, remarking that the latter closely resembles *Zalophus*. He separates the two on "the sum of small differences in the skull, the great distance between breeding ranges, and the intuitive feeling that when more is known about *Neophoca* its distinctions will be confirmed."

Scheffer supposes that the evolution and dispersal

of the pinnipeds has been more or less linear and one-dimensional. The ancestral pinnipeds, having once made their entry into the ocean, probably in tropical or subtropical waters, spread out in long thin lines along continental borders and then along ice fronts in arctic and antarctic regions. This linear dispersion lent itself better to clinal variation than the usual fan-wise dispersion, which has resulted in the evolution of so many distinct forms in what seems to be a rather monotonous environment.

In his systematic account the author has carefully reviewed the taxonomic history of each taxon. All available reports of distribution are recorded, and the distribution of each species is mapped.

The last chapter of the book is a synoptic key. Virtually every character that can be used in separating the various genera and species is crowded in. The result is that each one of a pair of choices takes up an average of nearly one-half page. An advantage to this is that the key can also serve as a check list of taxonomic characters.

BRYAN P. GLASS

SNAKES IN FACT AND FICTION.

By James A. Oliver. The Macmillan Company, New York. $4.95. xvi + 199 pp.; ill. 1958.

Aimed toward the general literate public, this book deals primarily with the most common controversial questions about snakes—the prodigiousness of their appetites, their speed, size, enemies, danger to man, their hearing ability, their role in all sorts of snake cults and snake-charming rituals, their occurrence in large numbers, and their "family life." Answers are supplied for these and other questions and, equally important, also the feeling of authority to back them up.

The feeling of authority stems from the severely critical appraisal of all information bearing upon the topics discussed. Where the data are clear the author shows a refreshing willingness to depart from the more conservative views previously held by herpetologists, yet where data are inadequate he holds no brief for credibility. Few items are viewed as "possibles"; they are largely categorized as black or white—acceptable or inacceptable. Writing as a scientist, the author drew the proper line between fact and fiction. However, the average reader is as much a romanticist as a scientist; his satisfaction requires the lure of the unknown as well as the stern reality of the known.

The undesirability of undeviating subservience to technical accuracy is exemplified by the lengthy maintenance that snakes are really not aggressive. The point is one of semantics. A distinction between two common extremes of temperament *can* validly be made. It might have been more of a service to recognize that fact and to state what the distinction really involves, than to make the equally valid point that *no* reactions of snakes are aggressive in the proper sense of the word.

The point was missed that one of the most insidious aspects of fanciful legend is the delightful glee in perpetuation even by those who well know better. An example is the repetition by Winston Churchill in his monumental *History of English-speaking Peoples* of the legend of Saint Patrick's exorcism of snakes from Ireland. The time has not yet come when superstition in any form can be fostered harmlessly, or when all who now hear sheer fabrications are so sophisticated as to recognize them, like Alice in Wonderland, for what they are.

Despite these minor criticisms Oliver's severely rational treatment of the most common popular misconceptions about snakes is a real service to the literate world—a necessary and palatable purge from a literature and folklore much too congested with fancy and emotion.

HOBART M. SMITH

BIRDS OF VOLCÁN DE CHIRIQUÍ, PANAMA. *Fieldiana: Zool., Vol. 36, No. 5.*

By Emmet R. Blake. Chicago Natural History Museum, Chicago. $1.50. (paper). ii + pp. 499–577 + 1 folding map. 1958.

ECONOMIC ZOOLOGY

BASIC ANIMAL HUSBANDRY.

By John M. Kays. Prentice-Hall, Englewood Cliffs. $7.00. xiii + 430 pp.; ill. 1958.

The author has succeeded in producing a very readable textbook using a system of organization long popular among writers of introductory books in animal husbandry. Approximately equal space was allotted to cattle, swine, sheep, and the horse. While the section on the horse is very well done, it is not realistic treatment to give this species equal billing with the meat animals in 1958. The importance of and techniques for judging livestock have been given major emphasis, and many pictures of prize livestock are included. Unfortunately, the impression is given that phenotypic selection is an end in itself, and that successful livestock breeders should be, first of all, good judges. Performance testing and the significance of more exact procedures such as measurements of growth rate, efficiency of feed utilization, carcass analysis, and the requirements for genetic evaluation have not been emphasized. While it is true that the sciences

of nutrition, genetics, and physiology are emphasized in more advanced husbandry courses, it is regrettable that an introduction to them has not been given in *Basic Animal Husbandry*.

FREDERICK N. ANDREWS

A SURVEY OF THE BEEF-CATTLE INDUSTRY OF AUSTRALIA. *CSIRO Bull. No. 278.*

By W. A. Beattie. Commonwealth Scientific and Industrial Research Organization, Melbourne. Free upon request (paper). 135 pp. 1956.

This comprehensive survey of the distribution and economics of the beef-cattle industry in Australia ends with some suggestions for needed scientific research that are interesting for their breadth. Not only are such programs recommended as the study of the adaptation of various cattle breeds to different environments (e.g., humid tropical coastland, coastal ranges, and semi-arid inland in Northern Australia), the control of diseases and parasites, protection against poison plants, problems of sterility, appetite, metabolic disturbances, and results of feeding concentrates; but also numerous problems relating to plant industry and the improvement of pastures, to the balance of nature involving even birds and feral animals, and to matters of food preservation are thought worthy of scientific investigation. Such breadth of view is highly commendable. It is fervently to be hoped that the administrators who must now plan the scientific programs will not fail to take advantage of the study and its recommendations.

INSECT PESTS OF FARM, GARDEN, AND ORCHARD. *Fifth Edition.*

By Leonard Marion Peairs and Ralph Howard Davidson. John Wiley & Sons, New York; Chapman & Hall, London. $8.50. x + 611 pp.; ill. 1956.

This standard textbook of applied entomology has gone through a sequence of hands since the first edition was published by E. Dwight Sanderson in 1912. Since the death of Peairs, who began collaboration with Sanderson in 1921, and revised the 4th edition alone, the task of revision has been assumed by Davidson. The revision has been painstaking, and has involved the reduction in space devoted to insect pests which have become less important in the United States, the inclusion of some 60 new ones, and major attention to extensive developments in the field of chemical control. The book is well-indexed and has numerous references, both as footnotes and in lists at the ends of chapters. The result is a comprehensive and concise treatment of the subject, informative rather than entertaining or thought-provoking.

It may be questioned whether the adopted separation between insects of a noxious or economically harmful kind, on the one hand, and those beneficial to man's interests, on the other, is a desirable basis of treatment for the subject of economic or applied entomology. The lop-sided point of view it may engender in the student is inimical, surely, to the cultivation of a broad biological appreciation of the interrelationships of insects with other insects, with birds and with other enemies, as well as with human beings. For a volume of the present size, the treatment of insect control by natural enemies seems very abbreviated and far too subsidiary in emphasis to the chemical measures of control.

BENTLEY GLASS

THE GARDENER'S BUG BOOK. *Completely rewritten and reset.*

By Cynthia Westcott; full color-illustrations of 102 pests by Eva Melady; 94 line drawings by J. E. Edmondson and Eva Melady. The American Garden Guild; Doubleday & Company, Garden City. $7.50. xxiv + 579 pp. + 36 pl.; text ill. 1956.

This second edition of a popular work for the gardener follows the original publication after an interval of 10 years. The book may indeed be completely rewritten and reset, although it was not difficult to find the passage concerning which Robert Matheson (*Q. R. B.*, 22: 81. 1947) wrote: "As the author sweetly reminds us, all bugs are insects and all insects are bugs; but she stretches this definition to include such garden pests as rabbits, dogs, squirrels, and their relatives, and I presume, she includes man himself." It has not, however, been equally thoroughly reorganized, and the amazing sequence of pests listed alphabetically by their common English names under main categories such as "Ants," "Butterflies," "Caterpillars," etc., makes it necessary to depend on the index, which is fortunately quite full. The chapter devoted to the alphabetical list of plant hosts, with the "bugs" that depredate them, is also helpful. The major expanded feature appears to be the list of garden chemicals. In general, the comments of the earlier reviewer of this book are still applicable. It will be of no use to the biologist, but may serve fairly well any gardener with a large store of common names of "bugs."

ANIMAL GROWTH AND DEVELOPMENT

MORPHOLOGICAL INTEGRATION.

By Everett C. Olson and Robert L. Miller. The

University of Chicago Press, Chicago. $10.00. xv + 317 pp.; ill. 1958.

Morphological Integration is a title that will attract many readers, since its subject, at the heart of biological investigation, successfully eludes most attempts to grapple with it. The title page provides no formal subtitle, but a description on the jacket delimits the content of the book as "the interrelationships of morphological characteristics of organisms as they contribute to the theory of evolution." The authors are geologists, with a primary interest in paleozoology, which sheds light on their ambitions to study integration not only in the extant individual organism, where heaven knows it is difficult enough to understand, but also on populations of organisms that have exhibited change in time either ontogenetically or phylogenetically.

Their method has been to express morphological integration by the association of measures, using the coefficient of correlation as the expression of association. The procedure followed was the measurement of single characters, expressed as linear dimensions in almost all cases, and the subsequent interrelation of the measures by simple correlation. The degree of association between quantitative characters is taken by the authors to be a sensitive expression of biological processes. Their central concept is thus that the morphology of an animal might be "completely represented by a series of linear measurements. The animal would then appear as a complex network of linear dimensions. In the ideal case, the *total* morphology is abstractly and objectively recorded. A time sequence of abstractions of the type just described thus records abstractly and objectively the *total morpho-change* through the time sequence. Analysis of the model is effected by partitioning the collection of morphological measurements into classes based on the degree of association. It is a fundamental assumption that underlying orders of biological significance can thus be ascertained, and in this way the model is used as more than just an abstract, objective way to record morphology."

The main body of the book is devoted to a development of the mathematical model, and to a formal analysis of what the authors consider integration in a variety of biological material: in *Pentremites*, an extinct Mississippian blastoid; in the dentition of *Hyopsodus*, an Eocene condylarth mammal, and of *Aotus trivirgatus*, the owl monkey of South America; in the skull of two species of the extinct amphibian *Diplocaulus*. One other extinct amphibian has been studied, and one Eocene teleost. Studies were also carried out on *Rana pipiens*, on *Sciurus niger ruwiventer*, and on several samples of domestic pigeons from a single breeding population; and an attempt has been made to consider ontogentic series in the postnatal albino rat. Previously published work on captorhinomorph reptiles is referred to but not discussed in detail here.

The authors defend their method as not only novel but also fruitful, in so far as the mathematically derived groups of measures (their ρ groups) have permitted the prediction of biologically associated groups of measures (their F groups) which are related to specific physiological functions. The validity of their conclusions can be judged only by those more intimate with the ways of statisticians than this reviewer. But whether or not their statistical treatments satisfy the experts, their concept of an animal as an abstraction based on an association of measures will be a challenging idea to those who find that the definition of an integrated animal defies them.

The authors claim that "expression of an individual animal as an array of measurements is in one sense equivalent to a verbal description or a series of drawings. An unordered array of measurements has about as much meaning as sketches of parts of the body entered on paper without regard to a reasonable anatomical organization. Ordering by systems of either measurements or drawings provides a synthesis in the form of a series of groups that have some biological meaning." Primates are visual animals, and extant Hominidae use language. How would a man born blind and aphasic, but not deaf, understand or describe the totality of an animal which we call organization?

The authors, feeling the necessity for a simple numerical statement of the extent or level of total integration, have described and derived an index of morphological integration, I_ρ. By the use of this index they can demonstrate that the rat has attained a high level of morphological integration at 20 days postnatally, which falls to a lower level by 40 days. What can it mean that a living rat is more highly integrated at an earlier stage than a later, or that, to take another example, integration in the lower teeth of the owl monkey is higher than that in the upper? Is it biologically significant that integration of the cheek dentition of the owl monkey, based on the study of 83 measurements, is low when compared to integration studied in such functional systems as the limbs or axial structures of various vertebrates?

The authors are quite correct in their contention that "detailed quantitative studies of temporally ordered anatomical changes and the attendant wealth of implications hold the key to knowledge that can be obtained in no other way." The question remains as to how limited is the knowledge opened by this particular key. There will be many who may wonder whether the concepts expressed by Olson and Miller do not raise more questions than they answer, including that which

underlies their whole fabric of thought, namely, whether integration itself evolves. But these are the most interesting questions of all biology, and the authors deserve not only a sympathetic hearing, but also much applause for their courage and originality in trying to attack them in a new way.

JANE OPPENHEIMER

RHYTHMIC AND SYNTHETIC PROCESSES IN GROWTH. *15th Symposium for the Study of Development and Growth.*

Edited by Dorothy Rudnick. Princeton University Press, Princeton. $7.50. vii + 217 pp. + 6 plates; text ill. 1957.

The first three papers are concerned with the characteristics of cultured biological systems. Puck discusses mammalian cells in tissue culture handled by techniques generally employed for microorganisms; Dulbecco considers RNA animal viruses grown on cell suspensions; and Klein reports on differentiation in plant tissue culture. In each of these papers the technical capacities, present research uses, and possible future applications to basic biological problems of these systems are considered.

In the next group of papers, Prescott describes the growth cycle in amoebae with respect to the division cycle, studied by weighing single amoebae by the Cartesian diver method. Pittendrigh and Bruce present, in a rather generalized form, an oscillator model for biological clocks, together with some of the experimental evidence they have gathered concerning biological clocks. Endogenous diurnal cycles of activity in plants were treated by Bünning with respect to light, temperature, metabolic conditions, and disturbing factors, e.g., mitotic poisons and anesthetics.

The third group of papers is concerned with biochemical evolution. Gaffron considers photosynthesis with respect to the origin of life; Blum, self-replicating systems; Strehler, energy transduction in photosynthesis; and Shapley, photosynthesis in respect to life on other planets. These last papers are all highly speculative. The first serves to point out the importance of the origin of porphyrin systems, together with their capacity to enter into photochemical reactions, and some possible mechanisms of their origin. The second considers the origin of self-replicating systems—the nucleic acids and some of the physical conditions and reaction mechanisms by which such systems might have come into being. Strehler discusses the thermodynamics of energy transduction in photosynthesis, and attempts to link the photochemical and biochemical parts of this reaction together. Shapley mentions the conditions that make it unlikely that life in anything but the most primitive form exists on other planets within our solar system, but at the same time makes the point that there are 10^{20} stars in the Metagalaxy, i.e., the universe of galaxies within our range of knowledge. All of these are capable or are potentially capable of forming solar systems and furnishing energy to support some form of life—probably very similar to life as we know it on earth.

While the individual papers in this symposium are interesting, and undoubtedly solid contributions from their respective areas of interest, it is difficult to see any interrelationship between the three groups of papers or, more specifically, how many of them would be of interest to embryologists in other than a general way, or to those workers concerned with the problems of differentiation and growth for whom these symposia are supposedly presented.

RONALD R. COWDEN

CONTRIBUTIONS TO EMBRYOLOGY. *Carnegie Inst. Wash., Publ. 611. Volume XXXVI, Nos. 242 to 251.*

Carnegie Institution of Washington, Washington, D. C. $14.75 (cloth); $13.75 (paper). iv + 210 pp. + 60 pl.; text ill. 1957.

This volume contains 10 unrelated papers of a descriptive nature. The great majority are directly concerned with some phase of human development and are based primarily on material provided by the extensive Carnegie Embryological Collection. The volume is dedicated to Chester H. Heuser, a long-time member of the Department of Embryology, on the occasion of his 70th birthday. The methods used so skilfully and successfully by Heuser in preparing the valuable, early embryos of the Carnegie Collection for histological study are for the first time described and presented in this issue by Osborne O. Heard, a close associate and a participant in this work.

It will be recalled by readers of the *Contributions* that nearly 15 years ago the late G. L. Streeter set up 23 age groups (horizons) to indicate levels of development from the fertilized egg to embryos of 30 mm. in length (approximately 47 days of age). Beginning with Group XI, he carried the work forward through the remaining older groups. In the present volume Group X, including embryos having 4 to 12 pairs of somites, is described by Chester H. Heuser and George W. Corner. Eleven normal embryos of this age group, contained in the Carnegie Collection, are the basis for the report. Twenty-four others, which have been described or cited heretofore in the literature, are also listed.

Biologists, generally, are well aware of the fact that the basis for an adequate interpretation of anomalies must rest upon a thorough knowledge and understanding of the normal morphological development of the particular area or part affected. With this in mind two investigators have prepared papers, found in this issue, that are concerned with a reevaluation of the clinically accepted concepts regarding the abnormal development of specific parts: one by E. Ide Smith on the early development of the trachea and esophagus in relation to atresia of the esophagus and tracheoesophageal fistula; the other by Benjamin C. Moffett, Jr., on the prenatal development of the unique human temporomandibular joint. The morphological analysis presented by each of these investigators, obtained from a study of large series of closely graded normal embryos, makes it possible to question and perhaps discard some of the respective hypotheses and to suggest lines of evidence from which explanations may ultimately be attained.

Two interesting and detailed studies in development carried out from the viewpoint of comparative anatomy are to be found in this issue: one on the origin and development of the human extrinsic ocular muscles, by Perry W. Gilbert; the other on the development of the cranial venous system in man, by Dorcas H. Padget. Gilbert's investigation leads to the somewhat startling conclusion that the pattern of development of the extrinsic eye muscles of man is very similar to that of the cat, marsupials, birds, reptiles, and most, if not all, anamniotes. The author points out that most investigators heretofore have failed to examine critically very young mammalian embryos and have thus been misled by the condition in older stages in which the three pairs of extrinsic eye-muscle primordia have reached a rather advanced stage and have become so intimately associated that it is difficult to distinguish one from another. Padget's study of the cranial venous system is the outcome of her equally beautiful companion study on the development of the cranial arteries. The complex process of venous differentiation was broken down into 8 stages, each of which is illustrated by a series of appropriate drawings, permitting correlation with the arteries of the region. The basic pattern of venous development in man was clarified by detailed comparisons with similar stages in other vertebrates.

The results of an intensive reexamination of the development of the postotic portion of the human cranium and the upper cervical segments of a closely graded series of embryos is reported by E. Carl Sensenig. Included in this study are the development of the intersegmental vessels, somites, myotomes, occipitocervical ganglia, and roots of the hypoglossal nerve.

Chondrification in the hands and feet of a large and closely graded series of human embryos is communicated by Ronan O'Rahilly, D. J. Gray, and Ernest Gardner. Stages in the sequence of chrondriogenesis were established and correleated with Streeter's developmental horizons.

The remaining paper based primarily on human material is by Roy E. Crowder and is concerned with the development of the adrenal gland, from the first appearance of its primordium, in the 4th week, through the first few months of postnatal life. Special attention was given to the origin and ultimate location of specific cell types and to evidence in favor of the "cell-migration" theory.

The one paper of this volume not based directly on human material is by George W. Bartelmez and deals with the form and functions of the uterine blood vessels in the rhesus monkey. For this unusually careful and detailed study of the cyclic changes in the uterine vasculature, well injected uteri of 25 normal adult animals were examined in section, dissected optically, so to speak, and their branches followed under high magnification. From this comprehensive study certain vascular changes characteristic of the menstrual cycle can be correlated with those occurring in early pregnancy and interpreted as adaptations for insemination and the implantation of the ovum. This paper and, indeed, all those included in the volume are clearly and abundantly illustrated.

MARY E. RAWLES

CRUSTACEAN METAMORPHOSES. *Smithsonian misc. Coll., Vol. 131, No. 10.*

By R. E. Snodgrass. Smithsonian Institution, Washington. Free upon request (paper). iii + 78 pp.; ill. 1956.

ANIMAL MORPHOLOGY

A STUDENT'S HISTOLOGY.

By H. S. D. Garven. E. & S. Livingstone, Edinburgh and London; [Williams and Wilkins Company, Baltimore]. $11.00. xii + 650 pp.; ill. 1957.

This is a surprisingly complete text of histology for its size. It covers the major areas considered by the conventional courses in histology, but not in sufficient detail for most medical school courses. For an undergraduate zoologist, however, the book is excellent. It makes frequent allusions to the functional aspects of the structures under consideration, and some comparative histology is included. There are black-and-white illustrations as

well as some color plates. As an elementary textbook in histology, this book can be recommended with some enthusiasm.

R. R. COWDEN

THE FETAL PIG. *An Introduction to the Anatomy of the Fetal Pig.*

By Grace E. Holstad. Burgess Publishing Company, Minneapolis. $2.00 (paper) x + 42 pp.; ill. 1956.

This revision of a laboratory manual for the dissection of the fetal pig which appeared several years ago (*Q.R.B.*, 26: 307. 1950) differs from the earlier one mainly in improved typography and the addition of a number of drawings to illustrate the systems described. Except for the inclusion of a list of the individual bones of the skeleton (in which the palatine is listed twice, but the premaxillary not at all), the body of the text is unchanged. This is unfortunate, since revision surely presented an excellent opportunity to modernize and correct errors ("aesophagus" remains uncorrected to "oesophagus," or even better, "esophagus;" "coeliac" is also retained, but never "foetal"!), as well as to improve the general treatment, perhaps by adding a section on the muscular system, which is completely ignored.

As a laboratory guide this one suffers by comparison with Odlaug's manual (*Q.R.B.*, 29: 386. 1954), which is not only well-printed, but has an abundance of truly excellent drawings and an ample section on the musculature of the fetal pig, a form becoming ever more popular in the freshman biology laboratory.

FRANK C. ERK

THE ANATOMY OF THE HEAD OF *Ctenosaura pectinata* (IGUANIDAE). *Misc. Pub. Mus. Zool., Univ. Mich., No. 94.*

By Thomas M. Oelrich. Museum of Zoology, University of Michigan, Ann Arbor. Free upon request (paper). 122 pp. + 22 pl. 1956.

Among reptiles, according to the author, only *Sphenodon* has received anything like adequate anatomical description. For that reason a careful study of a large lacertilian, the Central American iguanid *Ctenosaura pectinata*, should be very valuable for comparative purposes. Thirteen specimens (8 male, 5 female) were dissected, and in addition 2 specimens of a second species of the genus were dissected for comparison. One specimen was serially sectioned, and stained for nerve relationships with the Bodian silver technique. Eight additional skulls were available for study, together with 3 representing other species of the genus. The plates and the detailed verbal descriptions should make this publication valuable to all comparative anatomists.

ANIMAL PHYSIOLOGY

SPEICHERUNG. *Stoffanreicherung im Retikuloendothel und in der Niere.*

By N. Jancsó. Adadémiai Kiadó, Budapest. $5.00. 468 pp.; ill. 1955.

In this book an attempt has been made to consider the process of phagocytosis and general enrichment of the cytoplasm with colloidal material as a physical-chemical event. Since this area has not been treated in book form elsewhere, it should be worthwhile from that point of view alone. On the other hand, the entire presentation is heavily weighted with the bias of the author, and most of the material presented stems from work done in his own laboratory during the last 25 years. From a material viewpoint, the binding of the volume is extremely poor, and so are the numerous (243) illustrations—particularly the colored ones. While the reproductions and binding are bad, the quality of the paper and printing is quite good. There is an appendix of technical methods which should be useful to those interested in this problem.

R. R. COWDEN

BIOPHYSICS AND GENERAL PHYSIOLOGY

LES FACTEURS DE LA CROISSANCE CELLULAIRE: *Activation et Inhibition. Exposés Actuels de Biologie Cellulaire.*

Edited by J. André Thomas; 10 contributors. Masson & Cie., Paris. 4,000 fr. (paper). xi + 425 pp. + 3 pl.; text ill. 1956.

The usefulness of this series of annual collections of papers lies in its content of routinely thorough résumés of the often neglected French literature on cellular biology. The overall quality of the different papers is quite variable, most strikingly so for the present volume. No volume could start off poorly with a review by Brachet, a clear-thinking man with a talent for writing. Brachet points out some very clever, but now familiar, correlations for protein-forming systems. An extreme change of pace is found in Delanay's historical and long-winded presentation on animal cell tissue culture media. Media for the culture of embryo tissues are discussed by E. Wolff. A well-written review by Thimann and Chouard lucidly presents problems concerned with the effects of plant auxins on growth. This article also contains an appended

bibliography of 655 references, mainly for the years 1947 to 1955 and nowhere else compiled. Two articles, respectively, by Dustin for animal cells and by Deysson for plant cells, discuss mitotic poisons. The volume closes with articles by May on grafts, by Gavaudan on narcosis of cells, and a general speculative piece on cancer cell growth by Oberling.

PHILIP E. HARTMAN

METABOLIC ASPECTS OF TRANSPORT ACROSS CELL MEMBRANES.

Edited by Q. R. Murphy. The University of Wisconsin Press, Madison. $7.50. xxiv + 379 pp. + 6 pl.; text ill. 1957.

The field that is the subject of this volume is an active one and the competition met by newly published symposia is keen. This volume comprises the papers and discussions of a conference sponsored by the School of Medicine of the University of Wisconsin, and held in 1955. The opening group of papers by Adolph, Darrow, and Ussing cover some general aspects of the field. Ion movements in intestine, muscle, heart, and nerve are reviewed by Visscher, Conway, Weidmann, and Shanes. There is a single paper on ionic exchanges in the kidney by Berliner (apparently at least one other paper on this topic was planned), and three views on gastric hydrochloric acid production are presented by Davies, Davenport, and Rehm and Dennis. There are 5 discussion sections in all: ionic transport in muscle and nerve, ion movements in the kidney, transfer of organic compounds across renal epithelium, secretion of gastric hydrochloric acid, and correlation of clinical problems and basic information relating to membrane transport.

The invited papers are by and large of high quality. The section on acid production in the stomach was particularly interesting. There is a critical review of previous work by Davies; Davenport attempts to tie together information on the metabolic aspects; and Rehm and Dennis report on their electrophysiological results and present a hypothesis to explain the findings. The discussion was spirited—there does not appear to have been any more agreement between the speakers at the end than at the beginning—but this does not detract in any way. Conway's paper on muscle is both controversial and stimulating. The discussion on nerve and muscle suffered from the absence of one of the main protagonists, but the editors have added a statement by him to the text for the sake of completeness. The other discussion sections were quite coherent.

The choice of topics and of speakers in an active field is always arbitrary. The clinical interests of the sponsors are reflected in the absence of papers on transport in plant cells as well as on the properties of artificial membranes. Given this limitation in scope, the book presents a good cross section of current work and thinking, and can be recommended to those interested in reading on these aspects of transport.

CHARLES EDWARDS

RED CELL STRUCTURE AND ITS BREAKDOWN. *Protoplasmatologia, Band X, 2.*

By Eric Ponder. Springer-Verlag, Wein. DM 40; $9.50 (paper). iv + 123 pp.; ill. 1955.

This authoritative monograph covers the structural aspects of the mammalian erythrocyte, but excludes consideration of the chemical aspects of hemoglobin and other components of the red cell. Osmotic hemolysis, its kinetics, and fragmentation, erythrophagocytosis, and effects of tissue lysins are discussed. The evidence provided by the electron microscope is summarized, with numerous good illustrations from the photographs.

The incredibly high price of this publication cannot pass without strong comment. At a cost of 7.5 cents per page it probably sets an all-time record, particularly since it is not even bound in hard covers. (The subscription price is only slightly lower.) Authors would perform a meritorious service to their colleagues if they refused to publish under publishers that charge so exorbitantly, whenever it is at all possible to secure publication elsewhere.

BENTLEY GLASS

X-RAY MICROSCOPY AND MICRORADIOGRAPHY. *Proceedings of a Symposium held at the Cavendish Laboratory, Cambridge, 1956.*

Edited by V. E. Cosslett, Arne Engström, and H. H. Pattee, Jr. Academic Press, New York. $16.50. xviii + 645 pp.; ill. 1957.

The papers and discussions of this symposium represent the work of many research groups with widely divergent backgrounds but a common interest in x-ray techniques at a micro-level. Several papers were presented by participants from the especially active x-ray groups at Cambridge, Delft, Moscow, Stanford, and Stockholm.

The first 400 pages of the volume are devoted primarily to the efforts of the physicist to improve the resolution of the x-ray microscopes, the microdiffraction instruments, and the Gabor diffraction techniques. Following the excellent introductory papers on reflection x-ray microscopy, contact microradiography, and point projection x-ray micros-

copy, 37 papers are organized under the following headings: (1) Tubes for contact microradiography; (2) Tubes for projection microradiography; (3) Design and construction of reflection microscopes; (4) Methods and techniques in contact microradiography; (5) Intensity and resolution in projection microradiography; (6) Microdiffraction; (7) Gabor diffraction; scanning methods; and (8) New imaging techniques; production of x-rays. These earlier portions of the book present a very comprehensive discussion of the present problems in the development of the point projection and reflection x-ray microscopes, as well as theoretical considerations for instruments of various design. The principal instrumentation problem is the development of an intense, finely-focused x-ray source—the same problem which confronts the crystallographer who is forced to work with small crystals.

In the remaining 250 pages of the publication, 24 papers are presented on quantitative microanalysis and applications of the x-ray microscope under the section headings: (9) Quantitative microanalysis; (10) Histology; biological application; (11) Medical and dental applications; (12) Metallurgical and other applications. These later sections are concerned primarily with the results obtained with contact microradiography, which is the only x-ray microscopic technique that has been developed sufficiently to permit routine application with commercially available equipment. The contributed papers concerned with biological applications of the contact x-ray microscope are devoted mainly to studies of light-opaque material, such as bone; to observations of mass concentration changes, as in the study of cancer tissue; and to applications where great depth of focus is desirable, as in the study of vascular networks.

The biologist interested in applying the x-ray microscope to routine studies of cell structure will find sections 1, 4, 9, 10, and 11 especially useful, complete, and up-to-date. With infrequent exceptions, the more theoretical papers are accessible to the biologist interested in the present stage of development of the x-ray microscope, for the physical principles involved are presented in such a manner that they usually can be appreciated by anyone with a thorough understanding of elementary physics.

The 4 introductory papers are to be highly recommended for the general knowledge fund of all science students.

R. M. Benolken

Vibrations Mécaniques Acoustique. *Physique Générale et Expérimentale.* *By P. Fleury and J.-P. Mathieu. Éditions Eyrolles, Paris.* 3,000 fr. 322 pp. + 4 pl.; text ill. 1955.

This treatise of acoustics includes sections devoted to vibratory movements in general, elastic waves, and the production and perception of acoustic waves. The four chapters in the last-named section include *one* which is of a biological nature, being concerned with the ear and audition; and the final chapter, which is devoted to musical and architectural aspects of acoustics, mentions briefly the acoustics of the human voice. From a biological point of view the entire treatment is very elementary and sketchy. Treatment of the organ of Corti is virtually lacking. The biologist who consults this book is most likely to be filled with amazement that it is thought possible to teach acoustics with almost no consideration of the organ of hearing. Would it be equally possible to find a treatise on light and vision which practically ignores the nature of visual organs?

Bentley Glass

BIOCHEMISTRY

General Biochemistry. *Second Edition.* *By Joseph S. Fruton and Sofia Simmonds. John Wiley & Sons, New York; Chapman & Hall, London.* $18.00. xii + 1077 pp.; ill. 1958.

Most biochemistry textbooks are written as if biochemistry courses are only sequels to other chemistry courses. Biochemical knowledge is generally treated as a static ensemble of very clearly and neatly *separated* topics: proteins, vitamins, hormones, etc. Biochemistry is also treated as a field with a scattered foundation and a nebulous future. Thus, it is no wonder that rare among these texts is a volume which supplies one with a background extensive, integrated, and up-to-date enough to push directly into current literature and research problems. The textbook by Fruton and Simmonds is a refreshing contrast. To read it gives one a feeling of the vitality and rapid expansion characterizing biochemistry today. Biochemical knowledge is presented not primarily for the factual and conceptual introduction it affords, but rather as a guide directly into present-day problems and advances. How do the authors achieve this?

Fruton and Simmonds first adopt a central theme. Attention throughout the book is directed toward protein molecules and their roles in biological catalyses. This is an achievement in the day of the specialist, in the day when nucleic acids so often dominate consideration as *the* biologically "vital" molecules! Of course, other molecules of bio-

chemical interest besides proteins receive due attention, but always in relation to the primary emphasis placed on enzyme catalysis.

Secondly, the authors present a wisely selected and extensive bibliography, cleverly annotated by leading authors and in the form of footnotes on the page where cited. This draws attention to publications of outstanding workers in biochemistry and to recent complete reviews for further reading. An extensive index concentrates on biochemical subject matter rather than on the names of authors and organisms, a policy reflecting the authors' philosophy of biochemical unity among living organisms. Bountiful structural formulae and figures, somewhat reduced in size and printed in clearer type in the revised edition, are of considerable aid to the neophyte in biochemistry. All of these facets make the book a ready source of information after the original course is completed. The book may also serve as a handy "refresher" for persons working in biochemistry or, especially, in the ever-increasing number of fields allied to biochemistry.

The freshness and timeliness of a volume of this type requires periodic revision, and not merely addition. A true revision is what the second edition in fact represents. Almost all of the original chapters have been carefully rewritten to include new information and references. A chapter on alternative pathways of carbohydrate metabolism has been added.

There are some questions that the purely enzymatic approach fails to cover in this text. How are the enzymes integrated in the cell? What is their origin? How are they controlled *intra*cellularly? How do they fit into the pattern of cellular physiology? Perhaps these are questions more appropriately posed in other contexts and courses. Certainly, with the thorough background in protein chemistry, enzyme reactions, and intermediary metabolism which the book provides, an interest in other areas of biochemistry should easily follow.

PHILIP E. HARTMAN

BIOCHEMISTRY OF THE AMINO ACIDS.

By Alton Meister. Academic Press, New York. $10.00. xiii + 485 pp.; ill. 1957.

This volume presents an admirable summary of the literature on amino acid biochemistry through 1956. The five divisions are concerned respectively with the nature of the naturally occurring amino acids, their role in nutrition, some general considerations of amino acid biochemistry and physiology, the details of the intermediary metabolism of these compounds, and abnormalities in metabolism.

The first section deals with each of the amino acids found as protein constituents, with many amino acids occurring as intermediary metabolites, with uncommon amino acids, and with naturally occurring derivatives such as peptides and keto acids. Their chemical properties and behavior are considered, and mention is made of the discovery, the natural occurrence, and the function of these compounds.

The chapter on nutrition presents a brief recapitulation of the historical aspects, but is primarily concerned with comparing the nutritional requirements of various animals and microorganisms as an introduction to the topic of intermediary metabolism. Amino acid antagonists are discussed in some detail. The problems confronting the nutritional investigator and the unresolved aspects of this field of amino acid biochemistry are indicated quite well.

Amino acid metabolism is discussed first in terms of the biological reactions which are common to many of the enzymes. Deamination, transamination, decarboxylation, racemization, and peptide bond synthesis are among the topics included. Some of the physiological problems, such as the transfer of amino acids across cell walls, are covered as well. Attention is then directed to a detailed consideration of the pathways and enzymes pertinent to the intermediary metabolism of each of the major amino acids in turn. This section is liberally provided with summarizing schemes which depict verbally the reactions of the metabolic pathways and interconnections between these pathways.

Having considered the normal biochemistry and physiology of the amino acids, the author turns to the subject of abnormal metabolism and the related clinical problems. The metabolism of ammonia is discussed in relation to its toxic effects. Inborn errors in the metabolism of tyrosine and phenylalanine (alkaptonuria, phenylpyruvic oligophrenia, and albinism) are described in detail, as are many of the abnormalities recognized in tryptophan metabolism. This final chapter effectively indicates the challenge in attempting to explain pathology in chemical terms.

The volume seems well suited to use as either a textbook or a reference book. The fine indexing, by subject and by author, contributes significantly to its reference value. The entire volume is well documented by literature citations. While the presentation of material is very concise, it remains quite readable.

K. J. MONTY

EFFETS BIOLOGIQUES DES RADIATIONS. ASPECTS BIOCHIMIQUES. *Protoplasmatologia, Band X, 3.*

By Maurice Errera. Springer-Verlag, Wien. $16.90 (paper). iii + 241 pp.; ill. 1957.

Errera has surveyed the data of approximately 1000 articles dealing with effects of ultraviolet and ionizing radiations on systems of biological interest. The survey has for its emphasis results obtained from experimentation on biological materials in vitro and in vivo; it delves little into biological implications of purely radiochemical phenomena. The usefulness of the survey lies in its organized presentation of a voluminous literature, dealing with complex studies often individually not too informative, but collectively of potential aid to the elucidation of mechanisms of radiation damage. Thus the reader may readily locate references, sometimes correctly cited, to original articles on specific subjects. Even a brief examination of the papers surveyed by Errera makes apparent some great deficiencies in published data on radiation effects, e.g., the lack of more than a few action spectra for photoreactivation and the presence of but few comparative studies on seemingly critical systems such as the radiation-sensitive *E. coli* B, radioresistant B/r system, etc.

PHILIP E. HARTMAN

RARE EARTHS IN BIOCHEMICAL AND MEDICAL RESEARCH. *A Conference Sponsored by the Medical Division, Oak Ridge Institute of Nuclear Studies, October, 1955.*

Edited by Granvil C. Kyker and Elizabeth B. Anderson. United States Atomic Energy Commission, Oak Ridge Institute of Nuclear Studies, Oak Ridge; Office of Technical Services, Department of Commerce, Washington. $2.20 (paper). xviii + 468 pp.; ill. No date of issue.

This bulky photo-offset of a typescript proceedings of a conference represents one extreme in the publication of symposium volumes. Cheapness has been attained at the price of permanence and general distribution. At the other extreme are expensively printed, permanently bound volumes, well advertised to the scientific public, but at a price often prohibitive. Time will tell which method of publication is better—perhaps it depends on the evanescence of the contents. At present, however, one cannot conclude from format and price which symposium volumes are superior in scientific merit and most deserving of a wide distribution and a long preservation.

The present volume contains 5 parts: Chemical Considerations (7 papers); Radioisotopes of Special Interest (2 papers); Pharmacological Considerations (4 papers); Biochemical and Metabolic Considerations (9 papers); and Possible Applications and Dosimetry (11 papers). Discussions are included after each group of papers on a common topic. The authors and participants unquestionably include most of the United States workers of reputation on cerium, yttrium, lanthanum, and other rare earths. There is an extensive index to the volume.

The volume is dedicated to the late Kurt G. Stern, biochemist, whose paper on the Interaction of Rare-Earth Compounds with Substances of Biological Interest (pp. 143–161) was his last scientific contribution.

MICROBIOLOGY

DERNIERS ASPECTS DU MONDE DES MYCOBACTÉRIES. *By Paul Hauduroy. Masson & Cie., Paris.* 750 fr. (paper). 92 + ii pp.; ill. 1955.

Hauduroy here considers in speculative vein the problematical relationships of other characteristics to virulence and "pathogenic power" among the mycobacteria; the value of cytochemical tests of virulence; the significance with respect to pathogenicity of the growth of colonies in S forms, i.e., "en torsades"; the coexistence of germs of different genetic nature in supposedly pure strains; the nature of certain abnormal strains of mycobacteria; and the sensitivity of various animal species to mycobacteria in experimental tests. Much here should be stimulating to workers in the field, and fruitful in suggesting new lines of experimental attack.

ADVANCES IN VIRUS RESEARCH. *Volume 5.*

Edited by Kenneth M. Smith and Max A. Lauffer, Academic Press, New York. $9.50. x + 376 pp.; ill. 1958.

This latest volume of an excellent series contains two general review articles on specific groups of viruses: J. B. Brooksby reviews the literature on the virus of foot-and-mouth disease; and H. A. Wenner discusses the psittacosis-lymphogranuloma group of viruses. In a challenging and creative critique, G. S. Stent puts forward three main proposals concerning bacteriophage multiplication and simultaneously marshals support from a scattered literature on this subject: (1) there is partial (assumedly structural) homology between some phage and bacterial genetic material; (2) mating is obligatory in phage reproduction; and (3) replication of deoxyribose nucleic acid takes place with a ribose nucleic acid template intermediate. In concentrating avidly on a positive integrated theme, Stent tends to neglect points of view alternative to his central theses; however, in this particular review, the omissions add all the more to the stimulating and provocative nature of the paper. A second review on bacterio-

phages, that of G. Bertani on Lysogeny, is the best-written and most complete review in English of this subject since that by Lwoff in *Bacteriological Reviews* (1953). Most appropriately following the two papers on microbial systems is an instructive article by L'Héritier on the hereditary virus of *Drosophila*. This article, expanded from a recent review in French (*Exposés Actuels de Biologie Cellulaire—Mécanismes d'Autoreproduction*, (J. André Thomas, ed.), Masson & Cie., Paris, 1957, pp. 57–80), contains much of interest to workers in all fields of virus research. The two closing articles provide thorough and informative discussions of virological techniques: one on complement fixation (by F. Fulton), the other on hemagglutination (A. Buzzell and M. Hanig).

PHILIP E. HARTMAN

HEALTH AND DISEASE

ANNUAL REVIEW OF MEDICINE. *Volume 7. 1956. Edited by David A. Rytand and William Creger. Annual Reviews, Stanford.* $7.00. 611 pp.; ill. 1956.

This is an excellent member of an excellent series of reviews. The specialist in each of the areas covered will find it useful to glance through the section devoted to his field, and check on the completeness of his own familiarity with the recent literature. In addition, in the scanning of other fields, he is bound to turn up profitable ideas and valuable new information.

Each of the articles is accompanied by an extensive bibliography, the prize going to the review of endocrinology, with 414 references. In Viruses of the Upper Respiratory Tract, G. G. Jackson investigates APC viruses and others. A. C. Barnes discusses recent evidence on the cause of toxemia of pregnancy. In a discussion of immunity, Sidney Raffel examines several fascinating areas such as properdin, agammaglobulinemia, and the exciting recent developments in the area of "immunologic paralysis," especially that occurring in the fetus as elucidated by Billingham, Medawar, and others. Presentation of this brief sampling is not intended to indicate that all the other reviews are anything but entirely worthwhile. The long annotated list of reviews, provided at the end under the editorial direction of the MacKays, and a recently added feature, is very useful.

VICTOR A. MCKUSICK

THE PETER T. BOHAN LECTURES ON MEDICINE. *First Series. University of Kansas Press, Lawrence.* $3.00. 128 pp.; ill. 1957.

This is an almost entirely pedestrian collection of seven lectures delivered at the University of Kansas at annual intervals between 1947 and 1954. As presented at the time, they must have been third-rate; as reviewed at this time, they contain little dividend for the reader's investment of time.

In the first lecture, by Russell L. Haden (1888–1952), there is a passable history of the development of knowledge about pernicious anemia. The second lecture, by Walter C. Alvarez (1884–), is the elder clinician's report on functional causes of discomfort in the abdomen. This appears to be an interesting and sound discussion, but such a judgment is tempered by the realization of how difficult objectivity and documentation are in this particular field. When John T. King (1889–) discusses the role of infection in the etiology of coronary artery disease and hypertension in the third lecture, one would think that Heberden himself was speaking. Possibly a clinician of the last century would be less startled by the ideas expressed. The recounting of instance after instance of coronary artery disease in which there was a history of striking tonsillitis in youth, points up the importance of the statistical method and of careful experimental design in clinical medicine. Possibly one of the better lectures is the fourth, delivered by Herman L. Kretschner (1879–1951), on the subject Urology and Internal Medicine. The lecture has no excessively ambitious objective, but is intended merely to discuss the area of overlap between the two specialties. There are two lectures of valedictory and semi-philosophical type: one is given by Claude F. Dixon (1893–) and the second by Paul D. White (1886–). Neither contains any stimulating new point of view. The final lecture, given in 1954 by Roy W. Scott (1888–1957), and entitled Prognosis in Coronary Artery Disease, is possibly the best of the lot, but would be more useful if supplemented by references to literature.

Moral: Guest lectures, often of dubious value in published form, should not be published ten years after delivery.

VICTOR A. MCKUSICK

MEREDITH'S SCIENCE OF HEALTH. *Third Edition. By Warren H. Southworth and Arthur F. Davis. McGraw-Hill Book Company, New York, Toronto, and London.* $5.00. xiv + 492 pp. + 8 pl.; text ill. 1957.

In a discipline as closely related to daily living as the science of health, sound pedagogy requires that textual sources be brought up to date from time to time. From a wide professional experience of writing and teaching in the field, the authors have

drawn the necessary materials and methods to prepare a third edition of this excellent work.

Following the same general plan of presentation that was used in the earlier editions, the writers have not only revised and augmented the original material to bring it up-to-date, factually, but have added entirely new chapters and sections dealing with such current and timely health topics as radioactive fallout, chemical and biological warfare, community resources and action in Civil Defense, etc. New illustrations, particularly those relating to the anatomy of the human body and to human reproduction and embroyology, contribute much of the quality of the volume, both as a college text and as a reference work.

The clarity of style, the dignity of presentation, and the authenticity of substance will undoubtedly maintain for the present revision of this fine textbook the same popularity earned by the earlier editions.

B. AUBREY SCHNEIDER

CORTISONE THERAPY *mainly Applied to the Rheumatic Diseases.*

By J. H. Glyn. Philosophical Library, New York. $10.00. x + 162 pp.; ill. 1957.

This little book reflects the author's experience in the treatment of rheumatic diseases with steroids and with corticotrophin (ACTH). The author's report on his own therapeutic work is most satisfactory. Not only the indications but also the techniques for intra-articular injections of steroids are discussed and well illustrated. Regrettably, the discussion of the use of steroids in diseases other than rheumatic disorders leaves much to be desired. The highly specific therapeutic effects of cortisone in adrenal virilizing hyperplasia are dealt with in two short paragraphs; however, the basic derangement of steroid metabolism in this condition is not discussed, and the rationale for this form of therapy is not explained. The discussion of steroid chemistry is too sketchy to be of any real value. For instance, the "18" position of the steroid nucleus is mentioned in the text but not shown in the diagrams. Despite these shortcomings and a high price, the book is recommended to physicians interested in the practical aspects of the treatment of rheumatic disorders.

W. FLEISCHMANN

THE LIPOPROTEINS. METHODS AND CLINICAL SIGNIFICANCE. *Symposia on Research Advances Applied to Medical Practice—No. 3.*

Edited by F. Homburger and P. Bernfeld. S. Karger, Basel and New York. $3.85. 94 pp.; ill. 1958.

HISTOPATHOLOGIE DU FOIE. *Le Diagnostic des Affections Hépatiques, Étude Iconographique.*

By P. Cazal. Masson & Cie., Paris. 4,800 fr. (cloth); 4,000 fr. (paper). vi + 207 + ii pp. + 2 pl.; text ill. 1955.

This is a comprehensive atlas of the histopathology of the liver, and should be useful to the experimental biologist as well as to the pathologist. Included is a consideration of the normal liver, the cardiac liver, lesions of the biliary system, secondary infection of the liver, viral hepatitis, toxic hepatitis, metabolic and endocrine lesions, cirrhosis, hepatic lesions during the course of diseases of the blood and blood-forming organs, hepatic tumors, and histopathological techniques for the study of the liver. Each section is well illustrated with plates; where desirable, diagrams have been included to simplify the interpretation. The text is rather brief and gives the novice in this area a simple but satisfactory coverage of the pathology under consideration. The chief value of this book lies in its profusion of excellent illustrations.

THE EFFECTS OF THE SULFONYLUREAS AND RELATED COMPOUNDS IN EXPERIMENTAL AND CLINICAL DIABETES. *Ann. N. Y. Acad. Sci., Vol. 71, Art. 1.*

Edited by Rachmiel Levine. The New York Academy of Sciences, New York. $4.00 (paper). 292 pp.; ill. 1957.

A conference on recent advances in the oral treatment of diabetes was held in New York City in July, 1957. The participants were outstanding scientists and clinicians active in the field. Progress in this field is so rapid that some of the information is already out of date 15 months after the symposium. The moderator, Rachmiel Levine, is one of the foremost investigators in this field. He stressed the great stimulus to basic research in carbohydrate metabolism due to the interest in these drugs. It seems that the sulfonylureas act by eliciting insulin secretion in animals and in human beings in whom a sufficient number of beta cells of the pancreas are present. Therefore, these drugs are most efficient in middle-aged patients with a relatively recent onset of diabetes. In juvenile diabetics the drugs are without effect. An introductory chapter by Loubatières of Montpellier, France, is of interest as a contribution to the history of scientific ideas in medicine. Loubatières has done most of the pioneer work on the effects of the sulfonylureas. The volume can be heartily recommended as an

introduction to the basic problems of oral treatment of diabetes mellitus.

W. Fleischmann

Précis de Gérontologie.

By Léon Binet and Fr. Bourlière; in collaboration with M. Aubry, P. Banzet, C. Bétourné, H. Bour, L. Carette, P. Castaigne, M. Conte, F. Cottenot, R. Couvelaire, J. Daric, A. Delaunay, R. Garneau, A. Larcan, Cl. Laroche, G. Mathé, C. Oberling, G. Offret, S. Paccaud, and P. Vernant. Masson & Cie., Paris. 3,800 fr. (paper); 4,500 fr. (cloth). viii + 554 pp.; ill. 1955.

One is immediately tempted to compare this work with the well-known *Problems of Aging* edited by E. V. Cowdry. There are indeed many points of resemblance, each work being a collection of chapters written by different authorities. In general, the American work took a rather broader viewpoint of the aging process; the present volume is more restricted to human aging, from a medical viewpoint. Neither work achieves the comprehensive biological view of aging to be found in Alex Comfort's recent book, *The Biology of Senescence*. However, from the geriatric point of view, this French volume is excellent, and the general introductory chapter, Problèmes biologiques généraux posés par la sénescence de l'organisme (Binet & Bourlière) contains much that is of general interest, although the effects of high-energy radiations on the life span do not seem to have been considered either there or in subsequent chapters.

The contributions cover the following subjects: the aging of aptitudes (Paccaud); age and infections (Delaunay); cancer in gerontology (Oberling & Garneau); the aging of the French population and its social and economic consequences (Daric); the blood and internal environment (Binet, Bourlière, & Mathé); arteriosclerosis (Delaunay); the aged heart (Vernant); respiratory system (Binet & Bour); digestive apparatus (Conte & Bourlière); the senile kidney (Laroche & Mathé); the prostate (Couvelaire & Larcan); locomotor apparatus (Bétourné); the skin (Cottenot); sense organs (Offret & Aubry); endocrines (Laroche & Bourlière); nervous system (Castaigne); gerontological surgery (Banzet & Carette); and therapeutic aspects of senescence (Binet & Bétourné). The volume includes a brief index, and is well illustrated. It contains a wealth of collected data, and must certainly be regarded as an important addition to the all too few reference works dealing with problems of aging.

Malaria. *Bull. WHO, Vol. 15, No. 3–4–5.*

World Health Organization, Geneva. $6.00 (paper). Pp. 361–862 + 2 folding charts; ill. 1956.

This valuable separate from the *WHO Bulletin* contains 24 papers and 16 shorter notes on the subject of malaria (paludisme). All papers are either in English or French. The aspects of the subject covered include a diversity of topics: theory of malaria eradication; insecticide resistance in mosquitoes; cytogenetic studies of *Anopheles*; the ecology and biology of mosquitoes; the geographic distribution of *Anopheles*; the epidemiology of malaria; the pathology of malaria; chemotherapy; and malaria control experiments in various regiones, e.g., tropical Africa, Madagascar, Western New Guinea, Borneo, Roumania, Jugoslavia, Nigeria. The authors are all men of experience in their areas of discussion.

It is rather surprising to find the highly important relationship, disputed at the time of publication but now widely accepted, between sickle-cell trait and malaria relegated to a short note. Written by Edington and Lehmann, however, this note presents an excellent, concise review of the subject up to the time of the report.

It is most regrettable that so large and otherwise useful a reference work has been issued without an index.

Food Poisoning. *Third Edition.*

By C. M. Dack. The University of Chicago Press, Chicago. $6.00. xii + 251 pp. 1956.

The new edition of this important work has been enlarged by 67 pages and increased in price by $2.25, an increase amounting to 3.5 cents per page of text over an interval of 7 years. Even so, the cost per page, now 2.39 cents, remains less than that of many other biological reference works and advanced texts. The greatly increasing danger of the effects of chemical additives to foods has been emphasized; new aspects of plant and animal poisons in foods, such as fish poisoning experienced by U. S. troops in the Far East, have been treated; and the accounts of *Salmonella* and other types of bacterial food poisoning have been brought up to date. Short but authoritative, with little technical detail but in place of it much illustrative case history, this work remains on the list of imperative reading for physicians, health officers, and teachers of health and hygiene courses, besides all persons concerned with problems of sanitation, the preservation and purity of food, or nutrition.

Notes on Atomic Energy for Medical Officers. *An Introduction to the Subject for Service and Other Medical Officers Who May Be Concerned*

with Defense against Atomic Bombs and Similar Problems.

By the Royal Naval Medical School. Philosophical Library, New York. $4.75. v + 169 pp. + 13 pl.; text ill. 1956.

The anonymous authors have prepared a concise, elementary manual on the physical nature and biological effects of atomic radiations. The biological chapters treat the subjects of The Life History of the Cell, Effects of Radiation on Cells, Effects of Radiation on the Body, and Treatment of Radiation Casualties. Although the information is predominantly physical, the biological views expressed are clear and up to date for the time of writing. The genetic effects would have profited from a consideration of the mutation studies of Russell on specific loci in the mouse; and there is far too much complacency because of the assumption that most mutations are completely recessive and do no harm until in the course of generations they become homozygous. The general subject of biological radiation damage has of course received so much attention in past months that, since the publication of the U. S. and British reports in 1956, the WHO report on genetic hazards in 1957, and the U. N. Report in 1958, earlier treatments of the subject already seem antiquated. Prompt issuance of a revised edition is thus required, if the manual is to remain of value to those for whom it was prepared and for others who want a concise, clear treatment of these topics. It must be added that for so small a book the cost (over 2.5 cents per page) seems exorbitant.

BENTLEY GLASS

THE CHRONICALLY ILL.

By Joseph Fox. Philosophical Library, New York. $3.95. xix + 229 pp. 1957.

A full realization of the total impact of chronic illness upon society is difficult to reach, not only because of its gigantic scope, but also because of its elusiveness of definition. In this carefully prepared, completely authenticated, and highly readable text, Fox has brought to the problem a wealth of practical knowledge and experience. Thus, for the busy physician, the social worker, the hospital administrator, or even the person suffering from a chronic ailment, the treatise provides at least a good working definition of the problem, and delineates many of its ramifications.

Following the principles envolved by the Commissioner on Chronic Illness, the following definition of chronic illnesses is set forth early in the discussion: "All impairments or deviations from normal having one or more of the following characteristics: 1) are permanent; 2) leave residual disability; 3) are caused by non-reversible pathological alteration in the patient; 4) require a special handling of the patient for rehabilitation; and 5) require long periods of supervision, observation, or care!" From this definition, the discussion leads into the major causes of chronic illness, as well as its effects, not only on the individual sufferer, but upon those responsible for his care, and even upon society itself. Included also are chapters relating to the social, economic, and psychological factors of chronic illness, particularly among the older portion of the population where it is most prevalent.

The author's major plea is for a more effective, humanitarian approach to the problem through better recognition of the individual's needs, better and more facilities and personnel for handling the problem, and better support from governmental agencies and private philanthropies to carry out the work. Special emphasis is given to the relatively new "Home Care Plan," which is proving highly successful as a technique for extending an arm of the hospital into the home to care for the chronically ill.

A bibliography of some 130 titles, a glossary, and a brief index conclude the volume.

B. AUBREY SCHNEIDER

INTEGRATING THE APPROACHES TO MENTAL DISEASE. *Two conferences held under the Auspices of the Committee on Public Health of the New York Academy of Medicine.*

Edited by H. D. Kruse. Hoeber-Harper, New York. $10.00. xvi + 393 pp.; ill. 1957.

A comprehensive review of this sizeable volume could be accomplished only by writing another book. The volume is unique in that it represents the collaboration of 48 outstanding authorities of various disciplines joined together in an effort to develop understanding of the complex problems of mental disease. The book presents the results of two conferences sponsored by the New York Academy of Medicine.

The first conference was originally planned to emphasize etiology. The organic, the experimental, the psychological, the psychodynamic, and the psychosocial positions are individually presented, after which a representative of each of these fields speaks from the point of view of interdoctrinal acceptance and another representative of each position speaks regarding interdoctrinal unacceptability. The remainder of the first conference is given over to the attempt to develop the groundwork for further efforts to integrate the various points of view.

Preceding the second conference, representatives of each standpoint were asked to reexamine their positions according to three criteria: what is de-

monstrable and certain; what is logical, probable, and presumptive; and what is possible. They were invited to amplify, modify, or take exception to the exposition on the tenets of their approach. The second conference, like the first, concerned itself anew with the areas of acceptance and unacceptance. The conference then broadened the scope of its examinations and considered such questions as interdisciplinary differences in concepts, values and relevance, the development and validation of hypotheses, and the role of the basic scientist in multidisciplinary research.

For the worker in any of the disciplines represented in the conferences, the book will be a most valuable source. Here will be found in one volume the positions of the various disciplines, their agreements, and their disagreements, in detailed discussions. The nonprofessional person will also find much of value in the short statements of the speakers for the various disciplines. Such readers may object to the lengthy verbatim discussions; indeed much of this material could have been deleted without any loss to either the professional or nonprofessional reader.

In general, however, the book should prove to be a most valuable source for anyone who is interested in the complex problems of mental illness.

G. Wilson Shaffer

PSYCHOLOGY AND ANIMAL BEHAVIOR

The Psychology of Sexual Emotion. *The Basis of Selective Attraction.*

By Vernon W. Grant. Longmans, Green & Company, New York, London, and Toronto. $4.75. x + 270 pp. 1957.

Grant has utilized an unusually wide selection of sources in an effort to develop some understanding in the difficult analysis of sexual attraction and attachment. The scope of the book is broad and includes attempts to deal with distinctions between the emotional and aesthetic and the genital-sexual. The author apparently undertook the task in recognition of the fact that a vast amount of attention had been given to the presentation of the physical side of sexual behavior and surprisingly little attention to other factors that might possibly explain the sudden strong attraction of one person to a particular person of the opposite sex. The early part of the book is devoted to an effort to show that the "amorous" emotion, usually sexual, is not always so, and to a recognition of the complexity of the psychology of sexual emotion.

Considerable attention is given to the strongly held contemporary view that amorous love is a "sublimation" and exists only when the sex impulse is blocked. Grant ultimately finds it impossible to reach a fair verdict on the truth or error of the sublimation theory. Yet he finds it impossible to think of the whole of sexual behavior and experience as being linked to the genital impulse, and says that the idea of sublimation or something like it is necessary. Attention is given to the modern and contemporary views of sexual emotion and to the apparent independence of the amorous emotion. The psychology of sexual choice is discussed at length and gives rise to many difficult questions. If the amorous kind of attraction is a "sublimation" of sensual desire, what in a particular instance arouses the desire to a degree that corresponds with the strength of attraction? If the attraction has a different origin, why is it evoked by certain persons and not by others? Careful and detailed attention is given the "attraction of opposites" and the mating of similars. The phenomenon of choice, or selective attraction, is stressed as the essential basis of the sexual emotion; and various interpretations of the meaning of choice are evaluated.

The author gives every evidence of having made a serious study of the difficult problems presented, and the references are excellent and complete. Some readers will be bothered by the frequency of quotations and the difficulty of determining the extent to which the author agrees or disagrees with historical points of view. The summary which states the author's own point of view is disappointingly brief, but that is perhaps understandable in view of the complexity of the problems examined.

G. Wilson Shaffer

Psychopathic Personalities.

By Harold Palmer. Philosophical Library, New York. $4.75. x + 179 pp. 1957.

This book is really a collection of essays on psychopathy in which the first essay is devoted to Psychopathic Personality. The stated purpose of the author, to achieve a mood of presentation of psychiatry acceptable to workers in other disciplines, has been accomplished most satisfactorily. The material is clearly presented and will be understandable even to the uninitiated. The style is excellent, and in each essay the clinical syndrome is clearly defined. The psychological and sociological impact of the writing is most evident in the discussion of Hysteria and Psychopathic Personality. Palmer, like others, sees these two groups as threats to free institutions, and his position is concisely stated.

Those who are interested in the point of view of the "Functionalist" will be disappointed, since the position of the organicist is uppermost throughout the essays. Palmer calls attention in the Preface to the fact that he has been critically influenced

by the writings of Freud. It will be difficult for the reader to find evidences of that influence. Indeed, even in the essay on Hysteria, where Freud's influence must blaze if it is to show at all, one finds the following words: "The whole Olympian drama (for Freudian mythology is but Greek mythology interpreted by a Jew in the 19th century Eastern European setting) is naturally cast in the 'family setting of Western Culture'."

The organic emphasis is best illustrated by the fact that the longest essay, by far, is the one on the Epilepsies and further by the fact that each essay closes with statements in regard to treatment emphasizing shock, coma therapy, and leucotomy. Only occasional reference is made to psychotherapy, and then usually in terms of catharsis and persuasion.

There are very few books that give as clear a description of the clinical syndromes in so few pages, and those on the epilepsies and schizophrenia are particularly excellent. Nevertheless, the lack of any attention to psychodynamics (not necessarily Freudian) leaves something to be desired.

G. Wilson Shaffer

HUMAN BIOLOGY

Ancestors and Immigrants. *A Changing New England Tradition.*

By Barbara Miller Solomon. Harvard University Press, Cambridge. $4.75. ix + 276 pp. 1956.

New England is still, or again, new, but as those who reside in it well know, is no longer England. My nearest neighbors, in a tract formerly owned by the grandfather of Dr. Oliver Wendell Holmes, bear family names brought from Armenia, Russia, Sweden, Ireland, French Canada, and Gaelic Cape Breton. A mile away in one direction is a Swedish Evangelical Church; a mile in another direction, a Roman Catholic College, founded, guided, and largely staffed, by an Order of Nuns transplanted from France. Five miles away is a convent whose members came from Lithuania; at about twice that distance are a Hungarian club, and a church whose members are almost entirely Hungarian. When the Governor of Connecticut gave the Commencement address at the above-mentioned college, in June 1957, this successor to a gubernatorial grandson of Henry Cabot Lodge referred to his adherence to the Jewish faith. The Governor of Maine proclaims descent from a Hungarian immigrant. The Governor of Massachusetts is of Italian parentage.

Comparable mosaics of nationality are to be found in a thousand New England regions, wherein lie 35 Roman Catholic colleges and a Jewish university—the former faith being in the majority in at least two states. Mrs. Solomon, through a profuse use of sources from press, pulpit, letters, articles, books, and speeches, tells the story of Yankee reactions to this invasion during the years before 1929, when limitations of immigration to 150,000 annually, with nationality quotas, were established.

Wilson D. Wallis

Man, *His Life, His Education, His Happiness.*

By A. da Silva Mello. Philosophical Library, New York. $6.00. vi + 729 pp. 1956.

This work, which has strangely gone through four editions in Brazil (the author's native country and home), is a vast, disorganized, even chaotic collection of musings, opinions, and doctrinaire statements about nearly every aspect of human existence. The author is widely read, and his opinions are frequently illustrated by anecdotes and examples from such diverse sources as Hippocrates, Galen, Plutarch, the *Koran*, and the *Bible*. Among more modern writers, the author evinces a preference for citing Rousseau and Bertrand Russell.

The author's intellectual procedure in this book is somewhat obscure. Conclusions and data from one science are used ad hoc to justify or illustrate arguments in another unrelated discipline, when scarcely a loose analogy is really to be found. If there is one thing that is nearly pervasive throughout the book (besides loose generalizations), it is the apparent influence of Wilhelm Stekel, noted disciple of Freud, with whom, according to the foreword, Dr. Mello worked "for several months." The generalizations which pervade the work are pseudo-Stekelian. Indeed, if it were possible to characterize this book in a single phrase, one might call it "a sexual interpretation of human culture." Unfortunately, the work is far less systematic than such a generalization might suggest, and the last 175 pages have little relation to earlier portions, but are devoted to the author's opinions about contemporary international politics, and particularly East–West problems.

James J. Hill

Poverty Point, a Late Archaic Site in Louisiana. *Anthrop. Pap. Amer. Mus., Vol. 46, Part 1.*

By James A. Ford and Clarence H. Webb; collaborators, Junius B. Bird and Michael Beckman. American Museum of Natural History, New York. $2.00 (paper). Pp. 1–136 + 6 pl.; text ill. 1956.

This extensive report on the progress of the field

work at the Poverty Point and Motley Mounds in northeastern Louisiana, and the study of the artifacts in the Poverty Point cultural complex, also contains evidence from carbon-14 dating that places the culture between 1500 and 100 B.C.

BIOMETRY

NONPARAMETRIC AND SHORTCUT STATISTICS.

By Merle W. Tate and Richard C. Clelland. Interstate Printers and Publishers, Danville. $3.95 (paper). ix + 171 pp. + 5 charts. 1957.

In recent years there have been two important developments in statistical methodology. The first may be described as shortcut applications of normal parametric statistics. All of these reduce computational labor substantially, and many of them are nearly as efficient as their standard prototypes, particularly when samples are small. The second development has been concerned with methods which require no particular assumptions about the form of the distribution from which samples are drawn. These methods are known as *nonparametric* or *distribution-free*, and they are particularly suited to biological data since the underlying nature of the distribution is very often unknown.

This book covers both shortcut and nonparametric statistical methods, although the emphasis is on the latter. The coverage is excellent. This book does a fine job of bringing together material which has, until recently, been available only in widely scattered periodical literature. The description of the various techniques is so lucid that a reader with only college algebra should be able to follow the examples easily. Numerous self-teaching exercises (with solutions in an appendix) should be invaluable for the research worker who wants to learn about these techniques on his own. Finally, there is a fine collection of statistical tables which are indispensable to the application of many of the methods discussed in this book.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

HANDBOOK OF SCIENTIFIC AND TECHNICAL AWARDS IN THE UNITED STATES AND CANADA *1900–1952.*

Edited by Margaret A. Firth. Special Libraries Association, New York. $10.00. xxiv + 491 pp. 1956.

The title of this work, which formed a project of the Special Libraries Association, gives a sufficient idea of its contents. The names of the societies making the awards are arranged alphabetically, and under each of these the chronologically arranged awards carry such pertinent references as any publications for which the award was given, any paper presented by the recipient when accepting the award, notations on the presentation of the award, and biographical reference to the recipient. Hence, if one is interested in finding out what persons have been awarded the Eli Lilly Award of the American Chemical Society or the Newcomb Cleveland Prize of the American Association for the Advancement of Science, all the relevant information is quickly obtainable. It would have been nice if the compilers, who have accomplished a truly meritorious task, had departed from their circumscribed task to include the Nobel Prize winners in science, too—but let us be grateful for what we have gotten. It is a fine piece of bibliographical work.

NUCLEAR RADIATION IN FOOD AND AGRICULTURE. *The Geneva Series on the Peaceful Uses of Atomic Energy.*

Edited by W. Ralph Singleton. D. Van Nostrand Company, Princeton, Toronto, New York, and London. $8.50. xii + 379 pp.; ill. 1958.

This book is a compilation of 28 papers presented at the Conference on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland, in August, 1955. The papers range from fairly complete reviews of the use of atomic energy in agricultural and food processing research to detailed accounts of fundamental research in radiobiology. The authors are outstanding scientists from many parts of the earth. Thus the book gives a bird's-eye view of applied and fundamental agricultural research conducted the world over with the aid of radioisotopes and high-energy radiation.

The book is divided into 8 parts. Part One includes three general reviews of the use of radioisotopes for agricultural production and food processing research in various countries. Other papers tell how radioisotopes are helping to solve Hawaiian sugar production problems, and present a detailed account of research with the C^{14} biosynthesis chamber at the Argonne National Laboratory. Part Two contains a paper from the U.S. and one from the U.S.S.R. on the role of radioisotopes in studies of photosynthesis. These papers are quite detailed and contain a great deal of valuable information.

Radiation research in plant physiology, plant pathology, and cytology is dealt with in the third section. Here are included interesting research papers on the stimulation of plant growth by low doses of ionizing radiation, relationship of natural root grafting to translocation of nutrients and disease organisms among forest trees, foliar absorption of plant nutrients, uptake and transport of mineral nutrients in plant roots, tracing fungi-

cidal action in plants, morphological and genetical effects of plants grown under gamma radiation, and cytological and chemical effects of radiation. One paper describing the use of radioisotopes in soil and fertilizer studies comprises Part Four. This is a valuable review paper, containing some 133 references.

Part Five includes 6 papers concerned with the genetic and biological hazards of radiation. These papers are not directly concerned with agricultural research but relate to the biological effects of radiation on humans, *Drosophila*, mice, and dogs. The editor states that these papers were included because of the widespread interest in genetic and biological hazards of nuclear radiation.

Part Six consists of an interesting and most appropriate paper which describes the genetic eradication by gamma radiation of the damaging screw-worm fly from the island of Curaçao, Netherlands Antilles.

The 4 papers of Part Seven discuss ionizing radiation in plant breeding and crop improvement. Techniques for inducing mutations in various kinds of plants are described, as well as an account of research concerned with the experimental control of the induced mutation process.

The final 2 papers (Part Eight) describe some of the research on the sterilization and preservation of food through high-energy ionizing radiation. Included is a discussion of the control of trichinosis by ionizing radiation and a review of the research during the past 10 years in radiation sterilization.

Although the book covers many areas of agricultural research, it is by no means complete in its scope. For instance, preference has been given to papers in the plant sciences. There are no papers on the use of radioisotopes in animal metabolism, nutrition, and physiology. To conform to the title of the book, inclusion of papers in this area instead of those on the biological hazards of radiation would have been more pertinent.

As might be expected from the nature of the Geneva Conference, most of the papers are technical research progress reports. They present only limited reviews of the literature and practically no consideration of past accomplishments and future potentialities of atomic energy in food and agricultural research. As is typical of any compilation of research data, much of the information in this book may be shortly superseded. There is some duplication and lack of continuity between papers within the various sections. A synthesis of the papers by the editor would have been helpful.

The volume will especially interest scientists actively engaged in certain phases of agricultural research. It may serve as a partial supplement to those who do not desire to purchase the United Nations publications which contain all of the papers related to food and agricultural research presented at the Geneva Conference.

R. A. NILAN

HANDBOOK OF BASIC MICROTECHNIQUE. *Second Edition.*

By Peter Gray. McGraw-Hill Book Company, New York, Toronto, and London. $6.00. ix + 252 pp.; ill. 1958.

In order to evaluate this book properly, the biologist connected with an academic institution must ask himself about the propriety of offering a special course in microtechnique, and if so, with what such a course should be concerned in this era of modern biology. Certainly this book was intended as a text for such a course. Were it to be given, it would seem desirable to include a description of techniques in current research use. Little evidence of any such orientation was found in the present volume. Indeed, it could probably best be described as too much for an elementary biology class, and inadequate for a special technique course.

RONALD R. COWDEN

PRINCIPLES OF BIOLOGICAL MICROTECHNIQUE. *A Study of Fixation and Dyeing.*

By John R. Baker. Methuen & Co., London; John Wiley & Sons, New York. $7.50. 357 pp.; ill. 1958.

The two areas mentioned in the title of this book have been greatly neglected in the formal coverage of most textbooks on either cytochemistry or histological and cytological technique. The present author has presented the results, mostly of his own experiments, or those of his students, with certain fixatives and dyes. These studies were carried out not only on the tissues themselves, but also on model systems of pure protein films, etc. The book is divided into two principal parts, the first dealing with fixation, the second with dyeing. In the first part, the reactions of fixatives with proteins, and with tissues and cells, are considered. This section is followed by a separate consideration of the primary fixatives, and of fixative mixtures. Under the section on dyeing, the chemical composition of dyes and their classification is given. Next, the direct action of dyes and the attachment of dyes to tissues by indirect means (mordanting) is discussed. Three chapters follow concerning differential dye action, metachromasy, and the blood dyes. There are two chapters on vital dyes, and the book concludes with a comparison between dyeing and the process of coloring. In the Appendix, there is one section on experiments concerning fixation,

and another on experiments in regard to dyeing. Two others deal respectively with the use of the word chromatin, and with spelling.

This book is in no way a handbook of histological technique. It is, as its title suggests, a theoretical work on fixation and dyeing. It will be chiefly of interest to those histologists and cytologists who are interested in the chemical interpretation of data derived from fixed and stained biological preparations. Whether or not all of the theoretical material presented will stand the test of reasonable time remains to be seen. At this present time, the work is unique, and should be greeted with considerable enthusiasm.

R. R. Cowden

Science Students' Guide to the German Language. *By A. F. Cunningham. Oxford University Press, London.* $2.00. xiv + 186 pp. 1958.

A satisfactory knowledge of the German language is a virtual requirement for most graduate degrees in the United States. The vocabulary learned in undergraduate instruction is often an inadequate foundation for reading the professional literature. For those who have had some formal contact with the German language, this book will be helpful in building a scientific vocabulary and in reviewing the grammar. To novices, it presents a complete coverage of the grammar, while using scientific terms in the illustrations and exercises as much as possible. In addition to all this, hints on the use of German dictionaries and many helpful crutches are supplied. At the end of the book there is a section of readings taken directly from scientific articles in the German language. The fields represented include chemistry, geography, geology, mathematics, engineering, bacteriology, and physics. Unfortunately, no readings in biology as such are included, although some of the readings in chemistry and bacteriology have general transfer value. Summing up, one may say that while it is by no means a complete preparation for reading scientific literature in German, this book supplies a good introduction for those who may wish to study the language for purely utilitarian purposes. It should be a good textbook for a beginning course in scientific German, and offer a good review for those faced with the problem of passing a required German "reading-knowledge" examination in a scientific subject.

R. R. Cowden

A Treasury of Superstitions. *By Claudia de Lys. Philosophical Library, New York.* $4.75. 317 pp. 1957.

This is a wholly delightful little survey of current superstitious beliefs and practices. The book is divided into 6 chapters, each dealing with a different class of superstitions: superstitions about birds, the human body, food, sicknesses and deformities, objects associated with luck, and numbers. Each chapter is conveniently divided into sections; for example, the bird chapter has a section on superstitions associated with each different kind of bird. Although the book lacks an index, the work as a whole is sufficiently well organized and the table of contents so thorough that the reader can find his favorite superstition with little difficulty.

The author does not attempt to explain all the superstitions listed, but the origins of those which are apparently traceable to folklore or primitive and other symbolic origins are given. Although this collection of superstitions does not pretend to be exhaustive, it should certainly be useful to the casual observer of human foibles. Ornithologists will find the first chapter, Our Feathered Friends, especially entertaining.

James J. Hill

THE QUARTERLY REVIEW OF BIOLOGY publishes critical reviews of recent researches in all of the special fields of biological science. The contribution should present a synthesis or digest of the researches and a critical evaluation of them. A mere synopsis of the literature without evaluation or synthesis is not desirable.

Theoretical papers are published occasionally, especially when such papers (1) include a critical synthesis of the literature bearing on the theory and (2) are likely to promote further research in a given field.

The article should be written in concise language, yet in sufficiently non-technical form as to be intelligible not only to specialists in other fields but to the general biologist as well. To this end the article should have a general introduction and a summary which enumerates one by one all of the principal facts and conclusions given in the paper. Interpretative diagrams and schemes are very desirable.

Material ordinarily taking the form of footnotes is set in small print and placed in the text and consequently should be written in a style so as to fit readily into the text. Acknowledgments are printed in the text in small type at the end of the article just preceding the List of Literature. Recent issues of the Quarterly should be examined for style as regards (1) section or subsection headings in the text, (2) literature citations in the text, and (3) List of Literature.

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CONTENTS

Chemical Aspects of Recent Hypotheses on Protein Synthesis
—*I. D. Raacke* (245–261)

New Biological Books:

Evolution of the Phytotron
—*Kenneth V. Thimann* (262–263)

Reviews and Notices (264–301)

Index (303–309)